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VOLUME 24 SEPTEMBER, 1950 NUMBER 5

BURLINGTON CONODONTS FROM IOWA

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ABSTRACT—Except in the Kinderhookian, Mississippian conodonts are rare in the Mid-Continent region of North America. However, a thin shale bed in the upper portion of the Burlington limestone of southeastern Iowa has yielded a small but rather varied assemblage of fragmentary specimens. These are illustrated and described in this report. The genera represented are *Euprioniodina?*, *Hibbardella*, *Hindeodella*, *Ligonodina?*, *Polygnathus*, *Prioniodina?*, *Prioniodus*, *Spathognathodus*, *Staurognathus?*, *Streptognathodus?*, and *Subbryantodus*.

DURING the last two decades, it has been shown that in the Mid-Continent region of North America the Kinderhookian series contains an abundance and variety of conodonts. Some of the faunas that have been described consist of a large number of genera and species. At the same time, careful sampling of the rest of the Mississippian system in this region has yielded relatively few specimens, and to date no published report has presented an abundant and diversified fauna. That is, studies of post-Kinderhookian Mississippian conodonts have involved much collecting, tedious examination of many samples, and few and fragmentary specimens. The material on which the present report is based is no exception to this pattern.

The conodont collection under consideration was obtained from a 6- to 8-inch bed of bluish-green shale on the north bank of Long Creek some 2½ miles south and 1½ miles east of Cotter, Louisa County, Iowa (that is, about 700-1000 feet north of the center of section 33, T. 75 N., R. 5 W.). The shale is very poorly exposed, but it lies between horizontal layers of moderately thick-bedded crinoidal limestone. Both Udden (1901, pp. 81, 88) and Van Tuyl (1925, p. 141) have classified rocks of similar lithology in this particular area (section 33) as upper Burlington, and there seems to be good reason to believe that they were correct. We did not, however, observe any fossils other than crinoid columnals in the poorly exposed limestone ledges.

Altogether we have only about 30 conodonts from this locality, and we are illustrating 22 of them. They seem to represent about 18 species distributed among 11 genera, but because of the incompleteness of the specimens these figures may not be precise. Furthermore, we are not proposing names for those individuals which do not seem to be referable to established species, for they would not make satisfactory types. Although small, this assemblage is nevertheless comparable in size to those described in the published studies of other Middle and late Mississippian conodont collections (see, for example, Branson and Mehl, 1941, 1941a, 1941b; Cooper, 1947, Roundy, 1926,

and Youngquist and Miller, 1949).

We are identifying and describing the Burlington forms as follows:

Euprioniodina? sp.
Hibbardella sp.
Hindeodella spp.
Ligonodina? spp.
Polygnathus aff. *P. sagittaria* Youngquist and Patterson
Prioniodina? sp.
Prioniodus cassilaris Branson and Mehl
Prioniodus spp.
Spathognathodus regularis (Branson and Mehl)
Staurognathus? sp.
Streptognathodus? sp.
Subbryantodus spp.

Because of the meagerness of this assemblage, and the lack of satisfactory faunas for comparison, little can be said concerning the stratigraphic significance of the collection we are studying beyond the fact that it is compatible with the upper Burlington assignment previously ascribed to the source bed. However, this collection elucidates a few trends in the composition of conodont faunas during the transition from early to Middle Mississippian times. *Polygnathus*, which was so abundant during the late Devonian and early Mississippian, lingered but seems to have decreased markedly in prominence by late Burlington time. However, forms which superficially resemble that genus but which have a more broadly excavated aboral platform surface (e.g., pl. 67, fig. 13) made their debut. Related genera such as *Pseudopolygnathus* and *Siphonodella* are not represented in our collection. *Hindeodella* is not abundant. *Ligonodina* persisted, being represented by specimens which are closely similar to those of Devonian and early Mississippian times. *Prioniodus* is prominent, and most of its representatives have a large laterally compressed cusp with the denticles of the bar relatively small, rounded, and, though closely appressed, distinct from each other. This type of *Prioniodus* is well developed in the Keokuk and Caney conodont faunas, and it contrasts with that typified by *P. alatus* Hinde. The latter is widespread and abundant in late Devonian and early Mississippian faunas; and it is characterized by large laterally compressed denticles, usually sheathed by bar material essentially to their apices, and therefore the presence of a bar which assumes a blade-like form.

Although no Burlington conodonts have been illustrated or described previously, their occurrence in Missouri has been recorded. That is, Branson (1944, p. 234) in discussing the formation in that state mentioned that "some fragments of conodonts have been collected, but none of the species has been identified."

We wish to acknowledge our indebtedness for help with this study. Mr. C. B. Campbell of Knoxville, Iowa, discovered and collected the specimens and donated them to the State University of Iowa. His continued interest and work in the collecting of conodonts has materially increased our knowledge of the occurrence of these fossils in Iowa. Professor Samuel P. Ellison, Jr., of the University of Texas advised us in regard to the generic affinities of certain forms. The photographs which accompany our text were retouched by Mr. Howard Webster of Iowa City, and the completion of the report was made financially possible by the Graduate College of the State University of Iowa.

SYSTEMATIC PALEONTOLOGY

EUPRIONIODINA? sp.

Plate 67, figure 1

We are uncertain in regard to the generic affinities of this fragment, and it may well belong in *Lonchodina* or some other member of the group of conodont genera which have large fairly close-set denticles arising from a bar. The specimen has rather short denticles which are strongly inclined and which are attenuately lenticular in cross-section. The bar material extends orad to partially sheath the denticles in a web-like structure.

Occurrence.—Upper Burlington limestone near center sec. 33, T. 75 N., R. 5 W., Iowa.

Figured specimen.—State Univ. Iowa, 4205.

HIBBARDELLA sp.

Plate 67, figure 17

Specimen bilaterally symmetrical. Median bar limb fractured but probably short. Lateral bar limbs very short—only one denticle is preserved on each side of the cusp. Originally there were probably no more than two denticles on each side of the cusp, and there may well have been only one. Pre-

served portion of cusp strongly recurved posteriad. This fragmental specimen is sufficient only to establish the occurrence of the genus *Hibbardella* in the Osage assemblage.

Occurrence.—Upper Burlington limestone near center sec. 33, T. 75 N., R. 5 W., Iowa.

Figured specimen.—State Univ. Iowa, 4206.

HINDEODELLA spp.
Plate 67, figures 8, 9

The collection being studied contains a few specimens that belong in the well known genus *Hindeodella*. The two illustrated are very fragmentary and are probably not conspecific. That shown by figure 8 (outer view) is somewhat blade-like and the denticles on it are small and numerous. Relatively large denticles are inserted at irregular intervals. Figure 9 (inner view) illustrates a specimen with a stout rounded bar which bears closely set denticles that are larger than those of the other individual figured and are irregular in size. On their aboral surfaces, both of these specimens bear thin attenuate median keels.

Occurrence.—Upper Burlington limestone near center sec. 33, T. 75 N., R. 5 W., Iowa.

Figured specimens.—State Univ. Iowa, 4207 (fig. 8), 4208 (fig. 9).

LIGONODINA? spp.
Plate 67, figures 6, 16, 18, 21, 22

Several fragmentary conodonts in our collection are reminiscent of *Ligonodina*. That represented by figure 6 presumably retains only the posterior portion of the bar. Figures 16, 18, 21, and 22 illustrate specimens each of which has a portion of the cusp and traces of the anticusp. Figures 16 and 21 show the latter structure retaining one denticle.

Occurrence.—Upper Burlington limestone near center sec. 33, T. 75 N., R. 5 W., Iowa.

Figured specimens.—State Univ. Iowa, 4209 (fig. 6), 4210 (fig. 16), 4211 (fig. 18), 4212 (fig. 21), 4213 (fig. 22).

POLYGNATHUS aff. P. SAGITTARIA
Youngquist and Patterson
Plate 67, figures 2–4

Specimen, which is incomplete anteriorly, in lateral profile is low, elongate, and only gently arched. Aborally there is a narrow eolongate escutcheon and, anterior and posterior to it, a prominent keel. In oral view, specimen is moderately bowed. The platform is asymmetrically divided by a prominent carina. Ornamentation of platform distinctly crenulates the edges but becomes indistinct toward the carina.

In its low elongate profile, this form is similar to *P. sagittaria* Youngquist and Patterson of the Kinderhookian Prospect Hill sandstone of Iowa. However, that species has a more nearly symmetrical platform, is narrower, and is only gently bowed; furthermore, it has ornamentation on the oral surface of the platform which is more prominent and persists farther toward the carina than does that of the specimen being studied. No other closely similar form seems to have been described. Uncertainty in regard to the size and shape of the anterior portion of the blade—a feature which varies considerably in *Polygnathus*—makes specific reference difficult if not impossible.

Occurrence.—Upper Burlington limestone near center sec. 33, T. 75 N., R. 5 W., Iowa.

Figured specimen.—State Univ. Iowa, 4214.

PRIONIODINA? sp.
Plate 67, figure 27

Cusp rounded on the outer (figured) side, but flattened on the inner side. Outer aboral margin of cusp is expanded laterally to encompass the escutcheon, which is relatively large and very deep. Bar limbs are broken off next to the cusp both anteriorly and posteriorly. This fragmentary specimen could perhaps be provisionally referred to *Euprioniodina* with about equal propriety.

Occurrence.—Upper Burlington limestone near center sec. 33, T. 75 N., R. 5 W., Iowa.

Figured specimen.—State Univ. Iowa, 4215.

PRIONIODUS CASSILARIS Branson and Mehl
Plate 67, figures 23, 24

Prioniodus cassilaris BRANSON and MEHL, 1941, Denison Univ. Bull., Jour. Sci. Labs., vol. 35, p. 186, pl. 6, figs. 11, 12, 15–17; BRANSON, 1944, Missouri Univ. Studies, vol. 19, no. 3, p. 240.

Cusp stout, and anticusp long and straight or slightly curved anteriorly. Both cusp and anticusp laterally compressed. Denticles relatively small, rounded, and closely appressed.

Occurrence.—Upper Burlington limestone near center sec. 33, T. 75 N., R. 5 W., Iowa. The holotype came from the Keokuk formation of St. Louis Co., Missouri.

Figured specimens.—State Univ. Iowa, 4216 (fig. 23), 4217 (fig. 24).

PRIONIODUS spp.
Plate 67, figures 25, 26

Several very incomplete specimens in our collection appear to be referable to *Prioniodus*, and we are illustrating two of them which are probably not conspecific. Figure 25 represents an inner view. The cusp is slender and is rounded in cross-section although it bears distinct anterior-posterior edges. The inner aboral margin is flared laterally to encompass a moderately large but shallow escutcheon, and a short anticusp is present. The denticles are strongly compressed and are fused at their bases. The specimen represented by figure 26 has a markedly compressed cusp which is sharpened along its aboral margin. The aboral margin of the cusp is essentially straight, and there is no distinct anticusp. The inner aboral portion of the cusp, which on many representatives of *Prioniodus* is broadly flared to encompass an escutcheon, is only slightly curved laterally for the escutcheon is represented by only a shallow narrow groove beneath the cusp. A portion of a single denticle is preserved immediately posterior to the cusp. The straight base, compressed nature of the cusp, and very small escutcheon appear to be distinctive of this form, which probably represents an unnamed species.

Occurrence.—Upper Burlington limestone near center sec. 33, T. 75 N., R. 5 W., Iowa.

Figured specimens.—State Univ. Iowa, 4218 (fig. 25), 4219 (fig. 26).

SPATHOGNATHODUS REGULARIS (Branson and Mehl)
Plate 67, figure 15

Spathodus regularis BRANSON and MEHL, 1938, *in* Branson et al., Missouri Univ. Studies, vol. 13, no. 4, p. 137, pl. 34, figs. 1, 2?, 3; COOPER, 1939, Jour. Paleontology, vol. 13, pp. 415, 420, pl. 45, fig. 38.

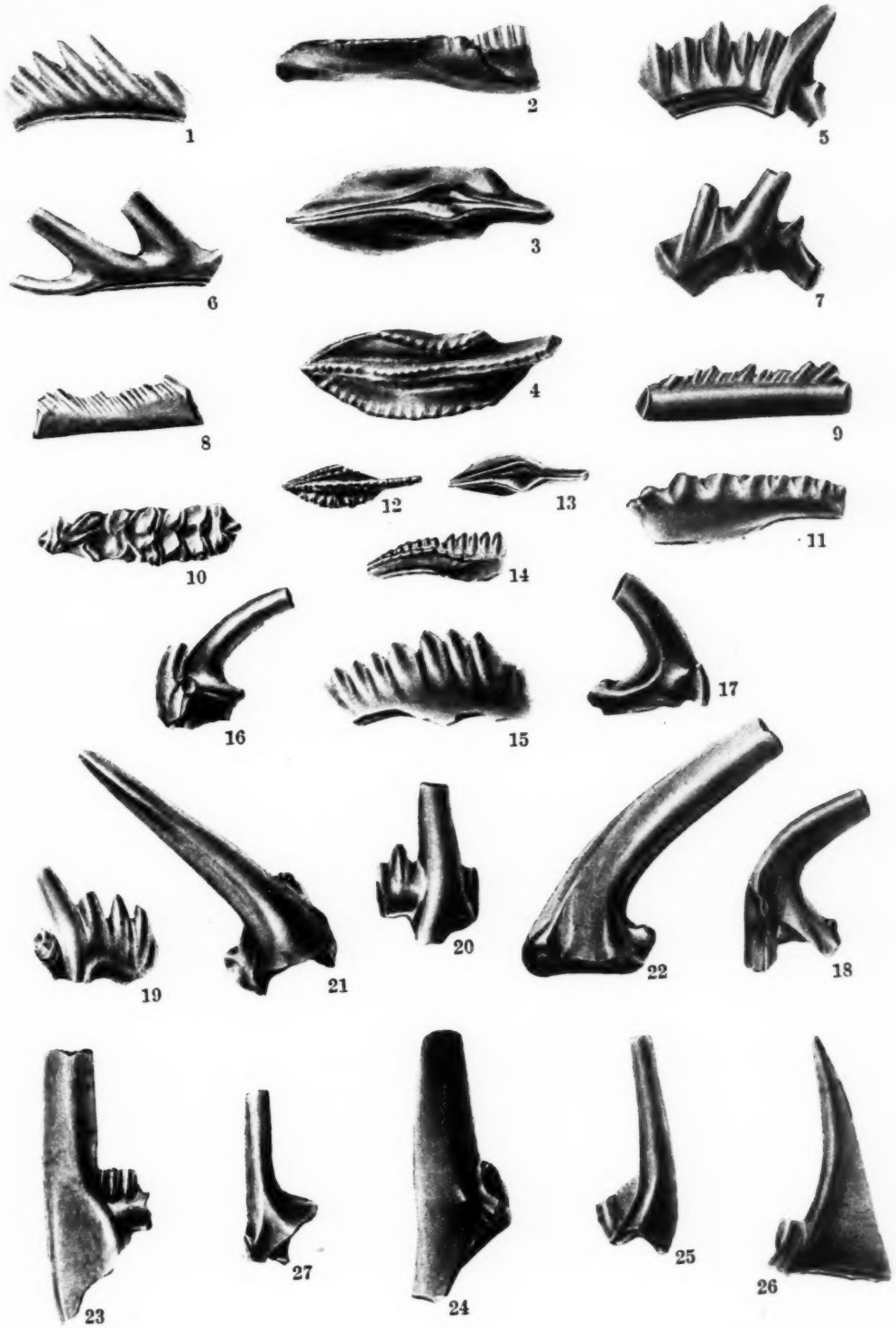
Spathognathodus regularis BRANSON and MEHL, 1941, Denison Univ. Bull., Jour. Sci. Labs., vol. 35, p. 187, pl. 6, fig. 7; BRANSON, 1944, Missouri Univ. Studies, vol. 19, no. 3, pp. 223, 240, pl. 39, fig. 10.

Blade, which is moderately arched and

EXPLANATION OF PLATE 67

All specimens illustrated on this plate are from the upper Burlington limestone of southeastern Iowa. All figures are ×40.

FIG. *1—Euprioniodina?* sp. (p. 526)
2–4—Polygnathus aff. *P. sagittaria* Youngquist and Patterson. (p. 527)
5—Subbryantodus sp. (p. 529)
6—Ligonodina? sp. Outer lateral view. (p. 527)
7—Subbryantodus sp. (p. 529)
8, 9—Hindeodella spp. (p. 527)
10, 11—Staurognathus? Two views of a fragmentary specimen. (p. 529)
12–14—Streptognathodus? sp. Three views of a single individual. (p. 529)
15—Spathognathodus regularis (Branson and Mehl). (p. 528)
16—Ligonodina? sp. Inner lateral view. (p. 527)
17—Hibbardella sp. (p. 526)
18—Ligonodina? sp. Inner lateral view. (p. 527)
19, 20—Subbryantodus spp. (p. 529)
21—Ligonodina? sp. Outer lateral view. (p. 527)
22—Ligonodina? sp. Inner view of large specimen. (p. 527)
23, 24—Prioniodus cassilaris Branson and Mehl. Inner lateral views of two individuals. (p. 528)
25, 26—Prioniodus spp. Inner and outer views of two specimens, respectively. (p. 528)
27—Prioniodina? sp. (p. 527)



Youngquist, Miller and Downs, Burlington conodonts

gently bowed, is set with several large denticles. The specimen is fragmentary, but the preserved portion of it and that which can be reasonably inferred indicate that it is similar to the types of *S. regularis*. The lateral margins of the blade, encompassing the escutcheon, are broken, but the escutcheon is almost certainly located posterior to the midlength of the blade.

Occurrence.—Upper Burlington limestone near center sec. 33, T. 75 N., R. 5 W., Iowa. Previously recorded from Chouteau and Keokuk strata in Missouri and from a "Bushberg-Hannibal horizon" in Oklahoma.

Figured specimen.—State Univ. Iowa, 4220.

STAUROGNATHUS? sp.
Plate 67, figures 10, 11

This fragmentary specimen is unique in our collection. Although incomplete at its larger end, it appears to be quite similar to certain of the lobes of the platform of the genotype of *Staurognathus*, *S. cruciformis* Branson and Mehl of the Kinderhookian Sycamore formation of Pontotoc County, Oklahoma.

Occurrence.—Upper Burlington limestone near center sec. 33, T. 75 N., R. 5 W., Iowa.

Figured specimen.—State Univ. Iowa, 4221.

STREPTOGNATHODUS? sp.
Plate 67, figures 12–14

We have a single individual which is reminiscent of certain representatives of *Streptognathodus* from the Pennsylvanian. The platform, which is concave orally and bears crenulate margins, is presumably symmetrical in shape—its apparent asymmetry in the oral view is due to the incompleteness of the inner anterior margin of the platform. Anterior extent of blade uncertain. Blade grades posteriorly into a carina which is high and prominent throughout the length of the platform. Aborally the platform converges almost to a V-shape and then flares laterally to form a thin flange-like structure which encompasses a long moderately wide escutcheon.

This form is not a typical representative of *Streptognathodus* for the carina is extraordinarily high and the escutcheon does not quite occupy the whole base of the platform. It probably cannot be referred to *Gnathodus* because of its oral ornamentation and the shape of its escutcheon. Neither is it typical of *Taphrognathus*, in which the platform is deeply trenched on its oral surface and a carina is absent or only faintly discernible. Except for the size and shape of its escutcheon, it might be referred to *Polygnathus*.

Occurrence.—Upper Burlington limestone near center sec. 33, T. 75 N., R. 5 W., Iowa.

Figured specimen.—State Univ. Iowa, 4222.

SUBBRYANTODUS spp.
Plate 67, figures 5, 7, 19, 20

Our most nearly complete specimen (fig. 5) retains most of the anterior and part of the posterior bar limbs. The anterior denticles are partially sheathed by bar material, but the distal third of their length is free. They are stout and are somewhat compressed. The cusp is recurved strongly posteriad, is rounded on the outer surface, and is somewhat flattened on the inner side; along the aboral inner margin, it flares laterally to encompass an escutcheon which is both large and deep and which extends as a narrow groove for some distance along the aboral surface of the anterior bar limb and also along the posterior bar. The posterior bar limb is much smaller than its anterior counterpart, and it retains a portion of one denticle which is rounded and apparently was discrete to its base. All of the other of our specimens assigned to this genus show the characteristics of figure 5 to a greater or lesser extent, depending largely upon their degree of completeness. Perhaps the most distinctive feature of these specimens, aside from their general physiognomy, is the persistent and consistent continuation of the escutcheon as a groove along the aboral surfaces of both bar limbs. This feature, Branson and Mehl (1934, p. 285) point out in their generic diagnosis, is one of the more significant of those which serve to distinguish *Subbryantodus* from *Prioniodina*, a closely related genus.

Occurrence.—Upper Burlington limestone near center sec. 33, T. 75 N., R. 5 W., Iowa.

Figured specimens.—State Univ. Iowa, 4223 (fig. 5), 4224 (fig. 7), 4225 (fig. 19), 4226 (fig. 20).

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JOURNAL OF PALEONTOLOGY, VOL. 24, NO. 5, PP. 531–565, PLS. 68–75, 9 TEXT FIGS., SEPTEMBER 1950

SIXTEEN ORDOVICIAN GENOTYPE TRILOBITES

HARRY B. WHITTINGTON

ABSTRACT—The genotypes of the following genera are redescribed: *Trinodus*, *Encrinuroides*, *Pterygometopus*, *Remopleurides*, *Robergia*, *Bronteopsis*, *Stygina*, *Raymondaspis*, *Homotelus*, *Ampyx*, *Ampyxina*, *Lonchodomas*, *Raphiophorus*, *Raymondella* and *Törnquistia*. These redescriptions are in most cases based upon a study of the holotype or syntypes. Only the holotype, a cephalon, of *Trinodus agnostiformis* is known from the type locality. The diplotype of *Encrinuroides* was a pygidium, and is now lost. An entire specimen, having a pygidium similar to one identified by the original author, is selected as neotype. *Pterygometopus sclerops* is of Lower Ordovician age, and quite distinct from species referred to *Calliops*. Portlock's original material of *Remopleurides* is redescribed and is believed to include three separate species. The genotype, *R. colbii*, does not have the long, forked hypostome known in certain American remopleuridids. The type and other material of *Robergia* has been re-examined, and the genus is represented in Scotland and the Appalachians. *Bronteopsis* is placed in the Scutellidae. The Styginidae thus includes *Stygina* and *Raymondaspis*. The former is described, but since the diplotype of the latter is lost it is considered that the name should not be used. It is suggested that the Styginidae be placed in the Corynexochidea. The genotype of *Homotelus* is shown not to correspond with the author's characterization of the genus and to differ from *Isotelus* only in what appear to be minor features. A neotype has been selected for *Ampyx nasutus*, of Lower Ordovician age. The genus is not known from rocks younger than Middle Ordovician. Material of *Lonchodomas* is redescribed, and the genus appears to range throughout the Ordovician. The syntypes of *Ampyxina* have not yet been recognized in the Rowley Collection, and topotypes are described here. The genus is placed in the Raphiophoridae. The holotype of *Raphiophorus setirostris* appears to be the only known specimen, and does not show all the characters of the cephalon. It is suggested therefore that the name *Raphiophorus* should be used at present only for the genotype. Specimens of *Raymondella* not previously figured are described and illustrated. The genus is placed in the Raphiophoridae. The diplotype of *Törnquistia* is a cranidium. Species referred to the genus suggest that it ranges from Middle Ordovician to Lower Silurian. The "hypostome" of *Phillipsinella* was described by Novák, and the genus placed in the Styginidae by Reed. Specimens identified as *P. parabola*, from Scotland, reveal that Novák's specimens were incomplete, and that the plate regarded by him as the "hypostome" is the rostrum. The true hypostome is redescribed. The genus stands alone, and is placed in a new family, the Phillipsinellidae.

INTRODUCTION

THE aim of this paper is to redescribe with new illustrations the genotypes of certain Ordovician trilobite genera. I am at present studying a large collection of silicified Middle Ordovician trilobites from Virginia. One of the first problems was to determine in which genus the various species should be placed. Published descriptions of the type species of many genera are inadequate, and steps were therefore taken to borrow type specimens for study and comparison. In most cases it was found that the types show features that have not previously been described, and in four cases the types could not be traced, though in all cases the names are in common use. This situation is a familiar one, and it was felt necessary to redescribe these genotypes in order to justify the names that will later be applied to the silicified trilobites. The selection of the genera here treated is an arbitrary one, based almost entirely on the needs of the work on the silicified material.

Knight (1941) has given a monumental account of Paleozoic gastropod genotypes and his work "deals with genotypes, not with genera, and with genotypes as established on type specimens" (Knight, 1941, p. 2). I have attempted to make the same approach, and give in the following pages an account of the name-bearing specimens, i.e. the diplotypes (Knight, 1936), of thirteen trilobite genera. Of the remaining three genera considered the diplotype of *Raymondaspis* is lost, and inadequate topotype

material was available to me, so that the genotype cannot be redescribed here. The types of *Ampyxina* have not yet been located, but topotypes are discussed. The discussion of *Phillipsinella* is based on specimens which are not topotypes of the genotype, but are probably conspecific, and reveal the structure of the ventral exoskeleton. A peculiar difficulty with trilóbites is that the diplotype is rarely a complete specimen, and even if so, it is a most exceptional specimen that shows the dorsal and ventral exoskeleton, including the hypostome and the course of the ventral sutures. In the present work none of the diplotypes is such a specimen. The holotype or the original author's syntypes have been obtaned for study, and a lectotype selected where necessary. The primary aim is to give a detailed description of the holotype (or lectotype, either being equivalent to the diplotype) together with such other topotype specimens (if available) that show the remaining characters of the exoskeleton. In most cases the material is sufficient to allow a complete, or fairly complete, description to be made. However, in the case of *Raphiophorus*, for example, the holotype is apparently the only known specimen, and it does not reveal the borders of the cephalon or the course of the facial sutures. A complete description of this genus cannot therefore be given at present, and it is recommended that the name only be retained for the genotype until more material is described.

In two instances neotypes have been selected, to fulfil the purpose suggested by Simpson (1945, p. 687), i.e., "A specimen attached to a previously published specific or subspecific name to serve as its name-bearer in substitution for the type." In both cases the types cannot be traced, and the neotypes have been selected from material coming from the original author's type locality. Little or no ambiguity exists in regard to these localities, and the specimens agree with the original figures and descriptions. In the case of *Ampyx nasutus* I have designated a neotype with the sole purpose of providing a name-bearer. The neotype of *Encrinuroides sexcostatus*, on the other hand, is the most complete specimen known to me, and is not only a suitable name-bearing specimen but a far more adequate type than the original, an incomplete pygidium.

I am in agreement with the views expressed by Simpson (1940) and Newell (1949) as to the function of types, and welcome the recognition of the hypodigm as a population sample. I have dealt with the types here as name-bearers, and in many cases only part of the exoskeleton is known, and rarely more than one complete specimen. Such material affords an extremely limited population sample, and it remains for future collectors to provide a larger sample from which the taxonomic species can be more fully understood than at present. It will be noted that few measurements are given in this paper. The relative proportions and size of the specimens is revealed by the plates, and in view of the incompleteness, distortion, and crushing of the material, it is felt that few useful or significant measurements can be made. Trilobites preserved in clastic sediments are almost always flattened and cracked, only those in limestone sometimes having the original convexity. This convexity makes the taking of measurements difficult, and another problem, for example, is that the length measured along the axis of wholly or partially enrolled and extended specimens is different. The only statistical study of trilobite species of which I am aware is that by Kaufmann (1933), and such work offers considerable difficulty.

No attempt has been made to give a diagnosis of each genus, for in the usual sense in which it is employed, this is a subjective account of the characters a particular author regards as diagnostic for that genus, based frequently upon several species referred to the genus. In the present state of knowledge of species of trilobites, no such diagnosis can be made.

ACKNOWLEDGEMENTS

This work would not have been possible without the ready and generous help that I have received from many individuals in institutions in Europe and America. These persons have made available to me type material in their charge, and furnished data on the geological age and locality of specimens. I express with pleasure my gratitude to Mr. R. Baker, British Museum

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Two of the genotypes discussed herein were studied during a visit to the United States in 1947. This visit was made possible by a grant from the Geological Society of America to Dr. G. Arthur Cooper. It is a pleasure to record my indebtedness to Doctor Cooper and to officials of the Society. The remainder of this study was undertaken at the University of Birmingham, and I am grateful to the Research Committee for grants both in support of my work and towards the cost of the illustrations. Mr. L. W. Vaughan and Mr. E. L. Stubley have taken great pains in preparing the prints and enlargements from my negatives, and the photographs forming plate 71, figure 10, plate 74, figure 10, plate 75, figures 1, 2, were kindly taken by the official photographer at the British Museum (Natural History). Dr. C. J. Stubblefield has maintained an interest in this work from its inception, loaned rare papers, and critically read the manuscript. I am deeply indebted to him, and to Professor L. J. Wills, for their interest and encouragement.

TERMINOLOGY

In the descriptions I have used the terminology of Warburg (1925, pp. 1–7), with two exceptions. The term *glabella* includes the area enclosed by the pre-glabellar and axial furrows, i.e., the occipital ring and furrow are part of the glabella. This is the original sense of the term, as Ross has pointed out (1948). The *glabellar furrows* have been numbered from the posterior forwards, the first (or basal) furrow being that next to the occipital furrow. Many of the specimens described here are preserved as counterpart moulds, and these are termed external and internal moulds. The former is of the outer, dorsal surface of the exoskeleton. The internal mould shows a combination of the inner surface of the dorsal exoskeleton and the outer surface of the doublure, as the casts made from these moulds reveal (e.g., pl. 72, fig. 10, pl. 75, fig. 4). If the exoskeleton is enrolled, the terms are used with reference to the cephalon (e.g., pl. 75, fig. 3 is termed an internal mould). Ambiguity may arise in the use of the terms "length" and "breadth" in description. Warburg (1925) used "from front to back" or "from side to side" in explanation. R. and E. Richter (1940, pp. 16–17) have recently suggested a terminology which is both brief and unambiguous, and is adopted here. Sagittal (sag.) is used to describe a measurement in the median line, exsagittal (exs.) parallel to, but outside of, the median line, transverse (tr.) at right angles to the median line. The abbreviations used are given in parentheses. Thus one can speak of the "breadth (sag.) of the anterior border of the cephalon," or the "length (exs.) and width (tr.) of a pleura."

DESCRIPTIONS OF GENOTYPES

Family AGNOSTIDAE M'Coy 1849

Genus TRINODUS M'Coy, 1846

Genotype.—By monotypy, *Trinodus agnostiformis* M'Coy, 1846

TRINODUS AGNOSTIFORMIS M'Coy, 1846

Plate 68, figures 1–3, text-figure 1

Holotype.—Nat. Mus. Ireland, no. IV, 3—an incomplete and distorted internal mould of a cephalon from the slates of Greenville, near Enniscorthy, Co. Wexford, Ireland, the original of M'Coy's plate IV,

figure 3. T. J. Duffy Esq., of the Geological Survey of Ireland, has kindly supplied the following information (personal communication) regarding the age of these beds:

As a result of the original Survey in 1855 the quarry in Greenville in which *Trinodus agnostiformis* was discovered was assigned to the lower beds of the Upper Silurian, and a line separating the Lower Silurian on the east from the Upper Silurian on the west was shown on the field map as passing immediately east of the quarry. On subsequent revision in 1900, however, the dividing line was removed and all the strata in the neighbourhood assigned to the Ordovician. On the published 1″ sheet the Greenville quarry is placed in the Llandeilo. A question mark is, however, placed after the word Llandeilo, and, apparently, it has not been found possible to separate these doutbful Llandeilo beds from the supposed Bala beds to the eastward

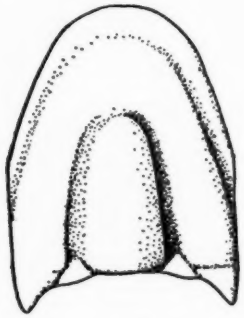


FIG. *1.*—*Trinodus agnostiformis* M'Coy. Dorsal view of the cephalon. The measurements on which this reconstruction is based have been taken from NMI, IV, 3 (pl. *68*, fig. *1*), which is distorted. The ratio of length to breadth, etc. may therefore not be the true one. c. ×8.

The originals of M'Coy 1851, Plate IE, figures 9, 10 are preserved in the Sedgwick Museum (Nos. A.11608, A.11609, see Woods 1891, p. 138). They consist of two poorly preserved incomplete moulds of cephala from the Rhiwlas Limestone of Rhiwlas, near Bala, Merioneth, of middle Ashgillian *Phillipsinella parabola* zone age. This species may or may not be conspecific with the form first described by M'Coy, but in either event the Sedgwick Museum specimens have no validity as "types."

Geological range.—Lower to Upper Ordovician. Kobayashi (1939, pp. 174–175) has referred seventeen species to this genus, ranging throughout the Ordovician system.

Description.—The cephalon is subsemicircular in outline, the length (sag.) greater than the width, convex, the height being about one-third the width. The glabella narrows slightly forwards, the length being about twice the width, rounded anteriorly, convex and standing high above the cheek lobes, sloping almost vertically down posteriorly; the occipital ring not preserved. The axial furrows are broad, deepest posteriorly, becoming shallower forwards, and continuous with the still shallower preglabellar furrow. At the posterior end the axial furrow bifurcates, one branch running inwards and backwards, the other outwards and backwards. A triangular lobe is thus isolated, which seems to belong to the occipital ring (text-fig. 1). The cheek lobes are convex, continuous with the preglabellar area, and slope inwards to the axial furrows, laterally descending vertically to the margin, anteriorly sloping less steeply down to the border; the width is constant and about equal to the width of the glabella. The anterior and lateral borders are continuous, flattened, separated from the cheek lobes by a very shallow furrow, most pronounced laterally; widest (sag.) anteriorly, becoming narrower anterolaterally, laterally disappearing as the genal angle is approached; the anterior and anterolateral margin a smooth curve, forming a distinct angle at the junction with the straight lateral margins. The cheek lobes descend vertically to the posterior marginal furrow, the posterior border is triangular in outline, the apex directed backwards and being the most posterior portion of the cephalon.

Discussion.—M'Coy (1846, p. 56) noted the presence of the triangular occipital lobes at the base of the axial furrow, and the holotype clearly shows the left hand of these lobes, although the posterior border of the cephalon is incompletely preserved (pl. 68, fig. 1). Neither Howell (1935, p. 234) nor Kobayashi (1939, pp. 174–176) mentioned these lobes when diagnosing the genus. Howell also stated that the exoskeleton was smooth. The holotype is an internal mould preserved in medium-grained cleaved rocks, and if any ornament was present, it is not preserved.

It was stated by M'Coy (1851, p. 141), and repeated more recently by Howell

(1935, p. 234) and Kobayashi (1939, p. 174), that *Arthrorhachis* Hawle and Corda 1847 is a synonym of *Trinodus*. I have compared specimens of the cephalon of *Arthrorhachis tardus* (the genotype, see pl. 68, fig. 6), with the holotype (and, so far as I am aware, the only known specimen from the type locality) of *T. agnostiformis*. The cephala of the Irish and Bohemian species appear to me to be similar in all essential respects. Since the Irish holotype is distorted it is difficult to compare proportions and convexity. *T. agnostiformis* has the posterior border drawn out into triangular points. In *A. tardus* the points are smaller and shorter.

The thorax and pygidium of *T. agnostiformis* have not been described from the type locality. Pending their collection and description, it seems best to assume that they will prove to be similar to those of the Bohemian species (pl. 68, figs. 4–6), and to regard *Arthrorhachis* as synonymous with *Trinodus*.

Family ENCRINURIDAE Angelin, 1854

Holliday (1942, p. 475) has proposed the name Cybelidae for this family on the ground that Whittard (1938) removed *Encrinurus* from the family Encrinuridae. I can see no justification for Holliday's statement, and Professor Whittard informs me (personal communication): "Emmrich founded *Encrinurus* on the characteristic pygidium figured by Wahlenberg, and this I have chosen as the holotype of *E. punctatus*. There is no doubt what Emmrich had in mind as regards the characteristic features of this genus and, so far as I can see, the genus is valid. In that case the family name proposed by Angelin is also valid."

Some fifteen genera (and subgenera) have been referred to the Encrinuridae. *Encrinurus* is very different from such forms as *Cybele*, *Atractopyge*, and *Cybelella* (Öpik, 1937, pp. 118–126), notably in that *Encrinurus* has a narrow rostrum, while that of *Atractopyge* is broad. It seems to me probable, therefore, that the genera now referred to the Encrinuridae are susceptible of division into two groups at least, and the name Cybelidae might be applied to one of these groups.

Genus ENCRINUROIDES Reed, 1931

Genotype.—By original designation, *Cybele sexcostata* Salter, 1848.

ENCRINUROIDES SEXCOSTATA (Salter, 1848)

Plate 68, figures 7–16; text-figure 2

Neotype.—The holotype, the original of Salter's plate VIII, figure 10, has not been traced (Stubblefield, 1938, p. 35). In the Turnbull Collection, SM A.30695a, b, is a complete specimen preserved as counterpart moulds, which is here selected as neotype. It is from the type locality of the Shoalshook limestone at Shoalshook, near Haverfordwest, Pembrokeshire, and of Upper Ordovician (*Phillipsinella parabola* zone of the middle Ashgillian) age.

Other material.—From the type locality, SM A.30692–4, 30696–9, 30701; GSM 24547 and 24549 (counterpart moulds, original of Salter 1853A, pl. IV, fig. 12. It is conceivable that one of these specimens is the holotype, cf. Stubblefield 1938, p. 35, footnote 1); BM I 1297, 16439, 16441, 16428. From the Rhiwlas Limestone (*Phillipsinella parabola* zone) of Rhiwlas, two-thirds of a mile north-northwest of Bala, Merioneth, SM A. 29192–4 (original of M'Coy 1851, pl. IG, figs. 6, 7), 30702–3; GSM 35427 (original of Salter, 1853A, pl. IV, figs. 1–4).

Geological range.—Middle and Upper Ordovician.

Description.—The entire trilobite is suboval in outline, the maximum width being two-thirds the length; the axis is strongly convex, the inner pleural parts flattened, the outer bent steeply down; the cephalon and pygidium are about equal in length (sag.), the thorax slightly longer.

The glabella is narrowest across the first lobes, and expands forwards to the anterior lobe, the width of which is about six-sevenths of the length; the highest point the center of the anterior lobe and high above the cheeks; in the mid-line at the anterior margin a short, shallow furrow, which on the inner surface forms a strong ridge. Three pairs of glabellar lobes are defined by deep furrows which run directly inwards from the axial furrows, the first pair almost reaching the mid-line, the second pair shallower and extending inwards to about one-third the width at that point, the

third pair short and shallowest; the length of the glabellar lobes increases progressively forwards, the third being twice the length of the first. The occipital ring is convex and stands above the basal glabellar lobes. The glabella is defined by the deep axial and preglabellar furrows, down to which the anterior lobe descends vertically. Deep anterior pits are situated at the junction of these furrows. The preglabellar field is vertical, about the same length (sag.) as the anterior border, which is vertical and continuous with the preglabellar field medially; laterally a broad, shallow anterior furrow separates the anterior border and the preglabellar field (af in text-fig. 2). The cheeks are triangular in outline, convex, descending vertically to the lateral borders, and separated from them by shallow furrows; the eyes are borne on short thick stalks situated on the central, highest part of the cheeks, and directed upwards and outwards. The posterior branch of the facial suture (text-fig. 2) runs directly out from the stalk, curving to cut the margin in front of the line of the posterior marginal furrow. The anterior branch runs forwards and inwards to cross the axial furrow immediately in

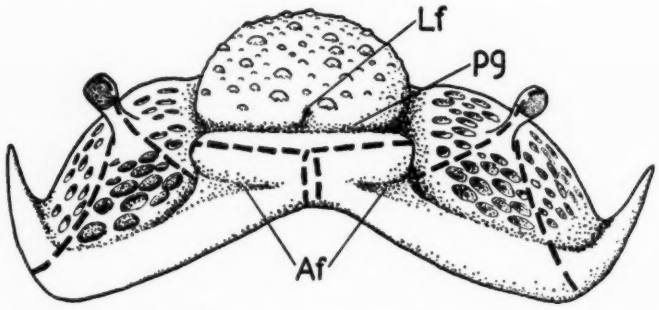


FIG. 2—*Encrinuroides sexcostatus* (Salter). Anterior view of the cephalon reconstructed from GSM 35427 (pl. *68*, fig. *15*), SM A.30696 (pl. *68*, fig. *8*), and A.30701 (pl. *68*, fig. *11*). The course of the facial sutures is shown by the dashed line. Lf, longitudinal furrow in the midline at the anterior margin of the glabella; Pg, pregalbellar furrow; Af, anterior furrow. c. ×3.

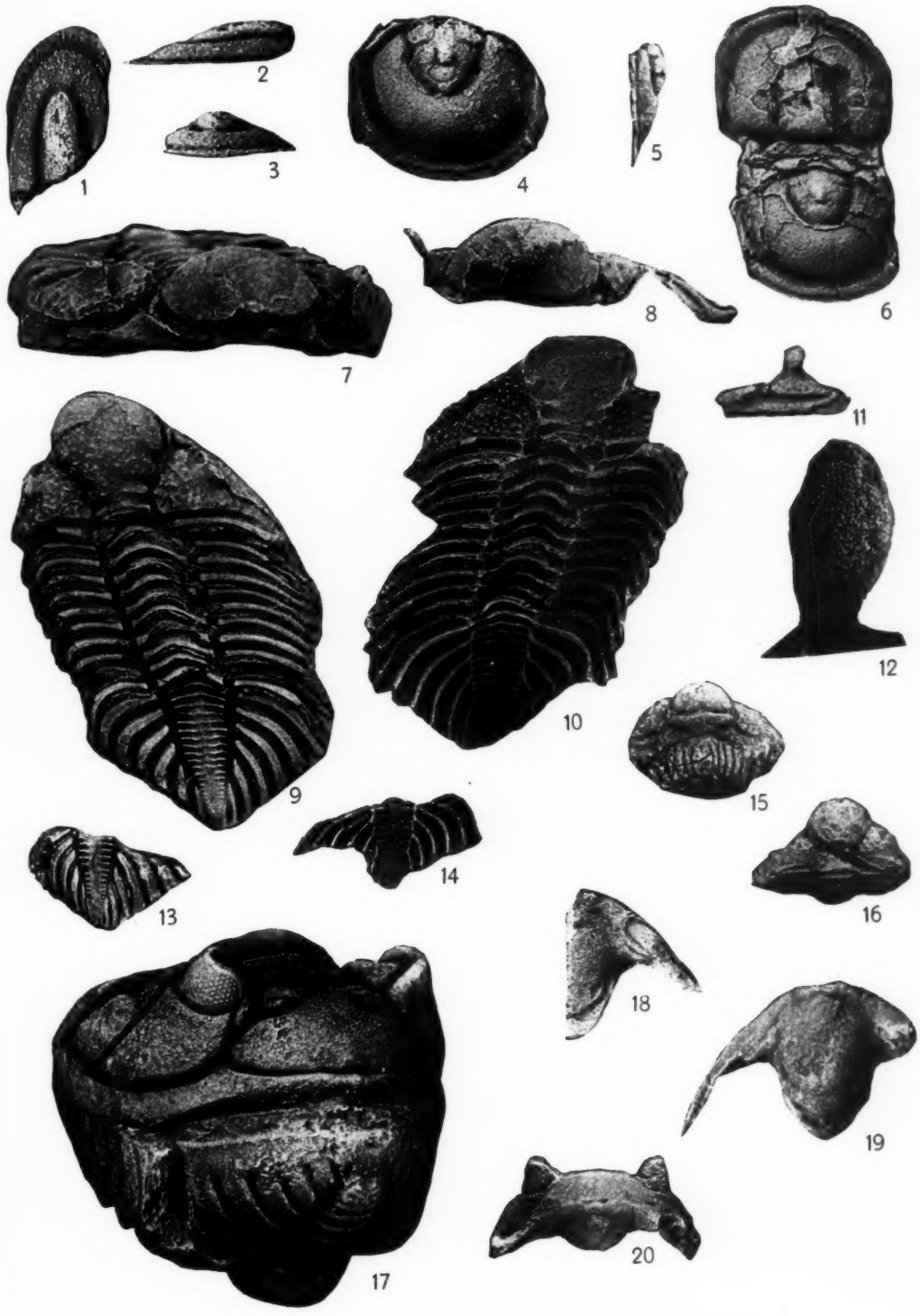
EXPLANATION OF PLATE 68

FIGS. *1–3*—*Trinodus agnostiformis* M'Coy. Dorsal, lateral and anterior views of the holotype, an internal mould the original of M'Coy 1846, pl. IV, fig. 3, ×6. Slates of Greenville, north of Enniscorthy, Co. Wexford, Ireland. NMI, IV, 3. (p. 533)

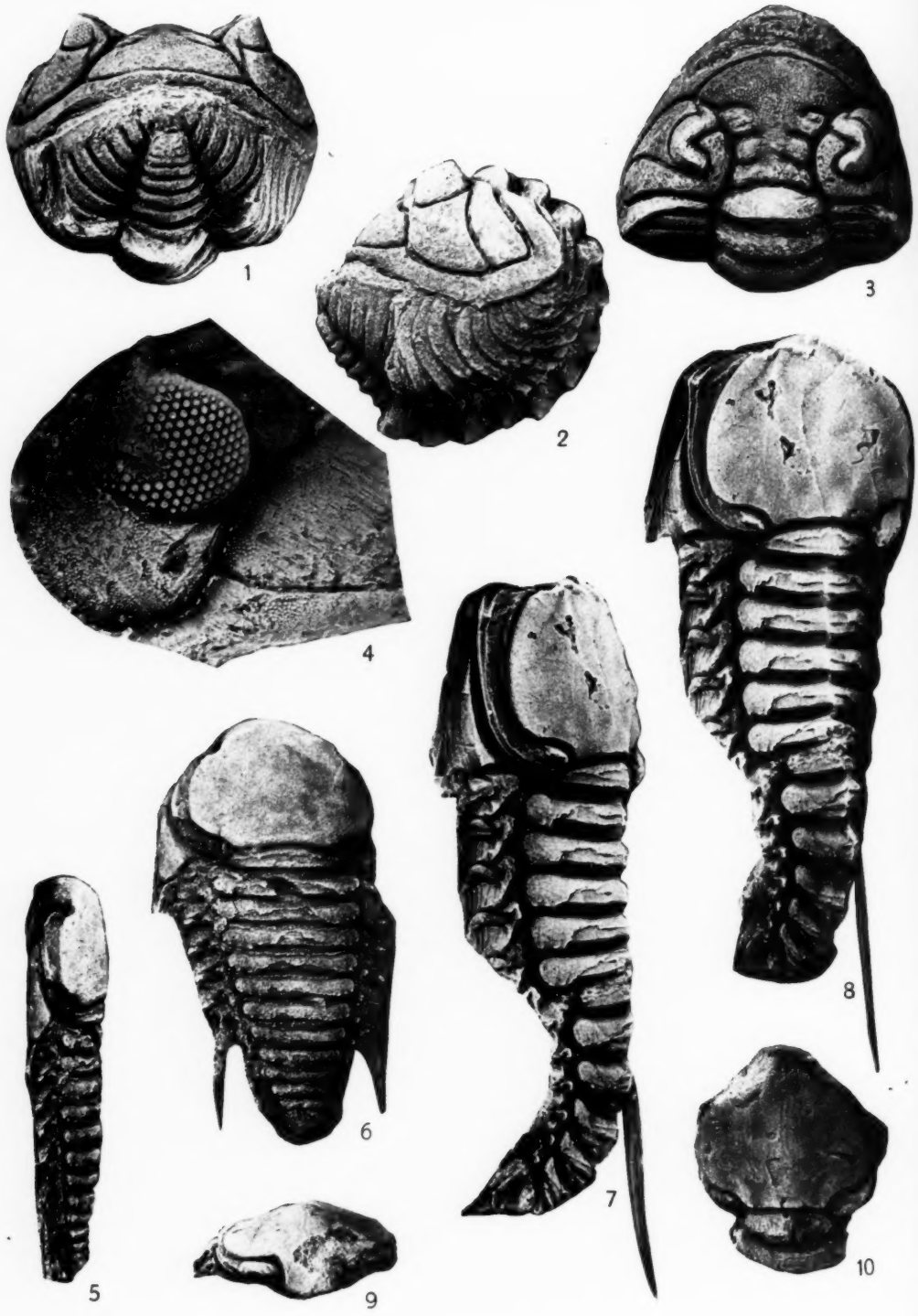
4–6—*Trinodus tarda* (Hawle and Corda). *4*, pygidium, internal mould, ×6. Králův Dvůr Shales, Königshof, Bohemia, BM In 42500. *5*, lateral view of pygidium, internal mould, ×6, Králův Dvůr shales, Králův Dvůr, near Beroun, C. Bohemia, NMP. *6*, internal mould, ×6, horizon and locality as fig. *4*, BM I 3422. (p. 535),

7–16—*Encrinuroides sexcostata* (Salter). *7*, *9*, *10*, anterior and dorsal views of the counterpart moulds of the neotype, ×2, ×1½, ×1½. Shoalshook limestone, Shoalshook, near Haverfordwest, Pembrokeshire, South Wales, SM A.30695. *8*, anterior view of cranidium with right eye stalk, internal mould ×2. Same horizon Shoalshook Railway Cutting, SM A.30696. *11*, *12*, free cheek and eye-surface, internal mould ×1½, ×10. Locality as fig. *8*, SM A.30701. *13*, *14*, counterpart moulds of incomplete pygidium, original of Salter, 1853A, pl. IV, fig. 12, ×1. Locality as fig. *7*, GSM 24547, 24549. *15*, *16*, anterior and dorsal views of enrolled specimen, original of Salter, 1853A, pl. IV, figs. 1–4, ×1. Rhiwlas Limestone, Rhiwlas, ¾ miles. N.N.W. of Bala, Merioneth. GSM 35427. (p. 535)

17–20—*Pterygometopus sclerops* (Dalman) *17*, anterolateral view of enrolled specimen, the holotype, original of Schmidt, 1881, pl. I, figs. 3a–c; pl. XI, fig. 1, and probably of Dalman, 1827, pl. II, figs. 1a–c, ×3. *Expansus* limestone of Västanå, Östergötland, Sweden, RS 18074. *18*, ventral view, showing half the hypostome and the adjacent doublure, ×3. Same horizon, Kungs-Norrby, Östergötland, RS Ar. 18049. *19*, *20*, ventral and anterior views of a cephalon, original of Lindström, 1901, pl. IV, fig. 3, ×2, ×3. Horizon and locality as fig. *18*, RS Ar. 18045. (p. 538)



Whittington, *Trinodus, Encrinuroides, Pterygometopus*



Whittington, *Pterygometopus*, *Remopleurides*

front of the anterior pit, and then continues along the outer edge of the preglabellar furrow almost to the mid-line. The narrow rostrum is isolated by the parallel connective sutures which run vertically across the preglabellar field and anterior border to the margin. The facial suture bisects the eye-stalk, and the visual surface is the upper part of the outer half. The lenses are small and numerous and the arrangement is shown in plate 68, figure 12. The posterior border is narrow (exs.) and elevated, the posterior marginal furrow deepest inwards. The genal angle bears a short spine.

The hypostome is unknown.

The thorax consists of 11 segments (in the neotype the first segment is pushed under the posterior border of the head shield, but the outer parts of the pleurae may be seen laterally). The axial rings are strongly raised and curve forwards to the mid-line. The articulating half-ring reaches forward to about half the length. The appendifers are short and thick. The axial furrows are shallow. The pleurae are short (exs.) and strongly raised, the inner part horizontal, the outer part of about equal width (tr.) and bent steeply down. The raised part has a blunt termination and the facet is broad. There are no pleural furrows.

The pygidium is triangular in outline, the length being about three-fifths the width. The axis reaches back close to the margin, is defined by shallow furrows, and flattened medially. Twenty axial rings are defined by furrows which are deep laterally, but become shallower medially and die out altogether in the posterior half so that beyond about the seventh ring the median part of the axis is smooth. Six prominent pairs of pleurae are defined by broad, deep rib furrows which are directed progressively more strongly backwards, and the sixth pair are parallel to the axis. Inside the sixth pair and behind the axis the neotype shows faintly a seventh pair and a median ridge. The termination of the pleurae is square, and there is a narrow vertical border.

The ornament of the glabella is of scattered tubercles of two sizes. The cheeks are coarsely pitted, with small tubercles on the intervening spaces. The thorax appears to be smooth, but on the axis and inner part of the side lobes of the pygidium there is an ornament of fine, closely spaced tubercles.

Discussion.—Salter (1848, p. 343, pl. VIII, fig. 10) founded this species on a pygidium. The cephalon which he originally figured (pl. VIII, fig. 9) with reservation as that of *Encrinuroides sexcostatus* is that of *Atractopyge* cf. *verrucosa* (Dalman), as Salter later recognized (1853 A, p. 4). Salter's later description was largely based on an entire but poorly-preserved specimen (pl. 68, figs. 15, 16) from a locality other than the type, a second pygidium only from the type locality being figured (1853 A, pl. IV, fig. 12, and see our pl. 68, figs. 13, 14). The pygidium of the neotype is identical with this latter specimen (compare pl. 68, figs. 9, 10 with 13, 14).

Salter (1853 A, p. 4, pl. IV, figs. 11, 12) distinguished two variations in the pygidium. The first was the presence of seven pairs of pleurae in a specimen from Rhiwlas. Seven pairs of pleurae are seen in the neotype and other specimens from Shoalshook. Figure 12 is inaccurate, as the original (pl. 68, figs. 13, 14) shows, and this specimen does not have the central part of the axis more free of ribs than others.

In the description the deep furrow which

EXPLANATION OF PLATE 69

FIGS. *1–4*—*Pterygometopus sclerops* (Dalman). *1–3*, anterior, lateral and dorsal views of the same specimen as pl. 68, fig. 17, ×2, RS Ar. 18074. *4*, antero-lateral view showing the eye-surface, ×6. Horizon and locality as pl. 68, fig. 17, probably collected by Dalman, RS Ar. 18080. (p. 538)

5–6—*Remopleurides colbii?* Portlock. Lateral and dorsal views, internal mould, original of *R. laterispinifer* Portlock, 1843, pl. I, fig. 2a, ×2. Killey Bridge beds, Pomeroy, Co. Tyrone, Northern Ireland, GSM 35553. (p. 540)

7–10—*Remopleurides ? dorsospinifer* Portlock. *7*, *8*, lateral and dorsal views, internal mould, original of Portlock, 1843, pl. I, fig. 3a, ×2. Horizon and locality as fig. *5*, GSM 13996. *9*, *10*, anterior and dorsal views of an incomplete cephalon with the first axial ring of the thorax, internal mould, original of Portlock, 1843, pl. I, fig. 4. Horizon and locality as fig. *5*, GSM 13997. (p. 542)

bounds the anterior lobe of the glabella has been called the preglabellar furrow (text-fig. 2). The area in front of this furrow is divided laterally by the shallow anterior furrow, and thus regarded as representing both the preglabellar field and the anterior border. This area, except for the narrow rostrum, is part of the free cheeks. Species of *Encrinurus* (e.g. Whittard 1938, pl. V, figs. 2, 3; Salter 1853 A, pl. IV, figs. 13, 14) do not show this preglabellar furrow, and it is one of the distinctive features of *Encrinuroides*. The outline of the glabella, the anterior medial furrow, the well-defined glabellar lobes, and the pygidium, which is broader than long, also distinguish *Encrinuroides*.

The range of the genus is given above as Middle and Upper Ordovician. Entire specimens (BM In 23288–90) of *Encrinuroides contentus* (Reed 1914, p. 39, pl. VI, figs. 11, 12; 1931, pp. 19–20) from the lower Middle Ordovician Balclatchie beds of Girvan, Scotland, have been examined, and show the characteristics of the genotype. Two specimens (BM In 23219, 23229) from the Upper Ordovician Drummuck group of Girvan show the characters of *Encrinuroides*, and should probably be called *E. trispinosus* (Reed, 1914, pp. 39–40, pl. VII, figs. 1–3). This species has a coarsely tuberculate cephalon and the pygidium proportionately longer than in *E. sexcostatus*. The specimens noted have 11 segments in the thorax and spines on the axial rings of the fifth and seventh segments, and on the pleurae of the sixth. *Encrinuroides* seems also to be represented by *E. seebachi* (Schmidt 1881, pp. 229–232, pl. XIV, figs. 16–26, pl. XV, figs. 21–23; Öpik 1937, p. 119, text-fig. 33) from the Upper Ordovician of the Baltic area, and the genus is also represented in North America.

Family PHACOPIDAE Hawle and Corda, 1847

Genus PTERYGOMETOPUS Schmidt, 1881

Genotype.—By subsequent designation of Bassler, 1915, p. 1065, *Calymene sclerops* Dalman, 1827.

PTERYGOMETOPUS SCLEROPS (Dalman, 1827)

Plate 68, figures 17–20; plate 69, figures 1–4; text-figure 3

Holotype.—RS Ar. 18074, from the Lower Ordovician (Arenig), Expansus limestone of Västanå (=Husbyfjöl), Östergötland, Sweden. This specimen was figured by Schmidt (1881, pl. I, figs. 3a–c; pl. XI, fig. 1) and Dr. G. Regnéll believes that it may well be the holotype figured by Dalman (1827, pl. 2, figs. 1a–c).

Other material.—RS Ar. 18075, 18078–18080, 18091 from the type locality; Ar. 18045–18049 from Kungs Norrby, Östergötland.

Geological range.—Lower Ordovician (Arenig).

Description.—The cephalon is subsemicircular in outline and strongly convex. The glabella is moderately convex, narrowest across the second lobes, expanding forwards so that the width of the frontal lobe is equal to the length. There are three pairs of subequal glabellar lobes, the furrows deep, the first and second running inwards and forwards, the third directly inwards and situated at a point about one-third the length. A faint shallow depression occurs in the frontal lobe of the glabella, situated centrally on the line of maximum width. The occipital ring is long (sag.) convex. The axial and preglabellar furrows are narrow and deep. The cheeks are convex, semicircular in outline, strongly bent down and almost vertical laterally, defined by narrow and deep lateral and posterior marginal furrows. The fixed cheeks inside and behind the eyes slope steeply down to the axial furrows. The eyes are curved and raised high above the glabella, the palpebral lobes crescentic in outline, convex. The deep palpebral furrow extends anteriorly to meet the axial furrow opposite the center of the third glabellar lobes, and is continued at the posterior end by a deep furrow running in a curve convex forwards across the cheek to the lateral marginal furrow. The anterior, lateral and posterior borders are convex and continued ventrally to form the narrow doublure, and are narrowest anteriorly; at the junction of the axial, preglabellar and lateral marginal furrows a triangular portion of the border projects inwards. The anterior branch of the facial suture (text-fig. 3) runs forwards and outwards, across the junction of the furrows and on to the border at the apex of the triangular projection, and then curves round to traverse the anterior border just outside the preglabellar furrow.

The posterior branch follows the continuation of the palpebral furrow out to the lateral border, across which it curves back to reach the margin just in front of the genal angle.

The hypostome is oval in outline, convex, the anterior margin strongly curved. There is no anterior furrow. The anterior wings are large, twisted to lie in the vertical plane, and situated opposite a point about one-third the length. The lateral borders are narrow, the posterior border broader, the lateral and posterior furrows shallow.

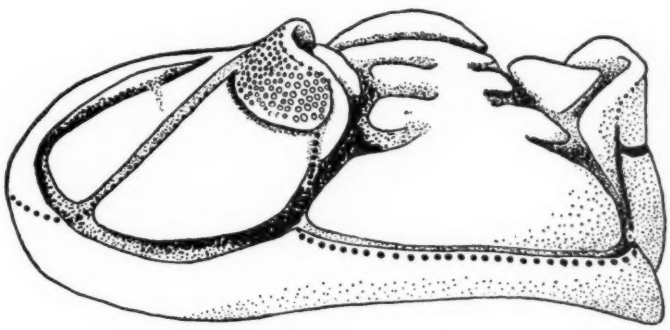


FIG. 3—*Pterygometopus sclerops* (Dalman). Antero-lateral view of the cephalon drawn from RS Ar. 18074 (pl. *68*, fig. *17*, etc.). The course of the facial sutures is indicated by the dotted line. ×4½.

The middle furrow is broad and shallow, commencing at a point about half the length and running diagonally inwards and backwards for a short distance.

Thorax of 11 segments. The axis about one-third the width. The inner parts of the pleurae flat, the outer parts bent steeply down and becoming longer (exs.) and with a rounded termination. Deep pleural furrows on the horizontal part, dying out beyond the fulcrum. The facets are large.

The pygidium is subsemicircular in outline, the termination not pointed. The axis is convex, bluntly rounded posteriorly, six rings marked by complete ring furrows, three further rings faintly indicated. The side lobes are bent steeply down, with five faint rib furrows and six deep pleural furrows.

The ornament of small, closely-spaced tubercles occurs everywhere except in the furrows of the dorsal surface. Coarser tubercles occur on the glabella.

Discussion.—Schmidt (1881, p. 79) states that the eye is composed of about 200 lenses arranged in 23–24 vertical rows, with nine to ten lenses in the central row, which is 2 mm. long. The eye in RS Ar. 18080 (pl. 69, fig. 4) is composed of some 275 lenses, arranged in 27 rows, the middle rows having 12–13 lenses and being of length 3 mm. Schmidt's figures show general agreement with the specimen RS Ar. 18045 (the hypostome of which was figured by Linström, 1901, pl. IV, fig. 3), but the holotype and RS Ar. 18080 are larger individuals and about the same size. The eye in the holotype is not well preserved, but appears to be composed of fewer lenses than RS Ar. 18080.

Schmidt (1881, p. 67) characterized *Pterygometopus* as a genus in which the frontal lobe of the glabella was extended laterally to merge into the border, and the anterior branches of the facial suture cut the frontal lobe laterally. In some species which he described (e.g., *P. sclerops*), the preglabellar furrow is present, but in others, e.g. "*P.*" *panderi* (1881, pl. I, fig. 15c) and "*P.*" *exilis* (1881, pl. I, fig. 19b) the preglabellar furrow is faintly marked, if at all, and hence the frontal lobe of the glabella is not clearly separated from the anterior border. In the case of these latter two species, Schmidt's characterization may be regarded as correct. In *Pterygometopus sclerops*, however, if one regards the preglabellar furrow as the anterior boundary of the glabella, then Schmidt's interpretation is not correct, for the anterior branch of the suture (pl. 68, fig. 17 and text-fig. 3) runs outwards and downwards from the eye in the base of a

furrow, and crosses the confluent axial and lateral marginal furrows opposite the point where they are joined by the preglabellar furrow. The suture then runs on to the point of the projection from the anterior border (this triangular projection points backwards and is defined by the lateral marginal and preglabellar furrows at their junction) and around the border just outside the preglabellar furrow. The projection is here interpreted as being part of the anterior border, but it is clear that Schmidt interpreted it (1881, pp. 78–79) as being a lateral part of the frontal lobe of the glabella. Thus within Schmidt's interpretation his characterization is correct, but if, as is usually understood (Warburg, 1925, p. 2; Howell et al. 1947) the glabella is bounded anteriorly by the preglabellar furrow, then in *Pterygometopus* the lateral parts of the frontal lobe are not cut by the facial suture.

It has been claimed (Roy, 1941, pp. 163–165) that *Pterygometopus* and *Calliops* (Delo, 1935) are synonymous. This statement is based, however, upon a misunderstanding of *Pterygometopus*, for Roy's figure 130a does not resemble the genotype. *Calliops* is not well founded, the diplotype having been lost (Delo, 1940, p. 95). Delo did not designate as neotypes either of the specimens used by him, and they are not well preserved. Topotype material identified by Hall, from Trenton Falls, New York, is preserved in the U. S. National Museum (No. 10111). I have examined all this material, and there is no doubt that *P. sclerops* is very different from *C. callicephalus*, as pointed out by Delo (1935, p. 417; 1940, pp. 91–92). In addition to the distinctions mentioned by Delo, there are the following: the lateral marginal and preglabellar furrows are present in *Pterygometopus*, thus the frontal lobe and borders are clearly demarcated; the eye in *Pterygometopus* is shorter and more strongly elevated, so that the fixed cheek slopes steeply inwards, and the palpebral furrow is continued across the cheek lobes by the curving furrow in which the posterior branch of the suture lies. *Pterygometopus* also has a deep furrow around the outer margin of the eye. In *Pterygometopus* the axial rings are parallel-sided, and the pleural furrows are deep and broad and directed straight outwards. In *Calliops* the lateral parts of the axial rings are curved forwards, and the narrow, deep pleural furrows are directed backwards as well as outwards. The pygidium in *Calliops* is proportionately longer, triangular in outline, and contains more segments. The hypostome of *Calliops* is very similar to that of *Pterygometopus*, except that the latter is much more inflated, has the lateral furrows proportionately closer to the posterior marginal furrows, and lacks the marginal spines (so far as can be seen). The mode of attachment appears to be identical.

Öpik (1937, pp. 73–74) has drawn attention to the way in which the palpebral furrow unites with the axial furrow at the anterior end in "*P.*" *exilis*. In *Calliops* (Delo, 1940, pl. 11) the palpebral furrow runs posteriorly into the posterior marginal furrow. In *Pterygometopus* the palpebral furrow is continued at the posterior end by a furrow which runs out laterally to the lateral marginal furrow.

Schmidt himself (1881, pp. 76–77) recognized that within the species of *Pterygometopus* described by him three groups could be made. The first of these included *P. sclerops* and *P. trigonocephala* Schmidt, the latter species being of the same age, and apparently having the same distinctive features, as the genotype. I consider that the name *Pterygometopus* should be restricted to phacopids of this type, and not be used for species of the types included in Schmidt's other two groups. It may be that certain of these latter species will prove to belong to *Calliops*. I know of no other species that can be referred with certainty to *Pterygometopus*.

Family Remopleurididae Hawle and Corda, 1847

Genus Remopleurides Portlock, 1843

Genotype.—By subsequent designation of Miller (1889, pp. 565–66), *Remopleurides colbii* Portlock, 1843.

Remopleurides colbii Portlock, 1843

Plate 70, figures 1, 2, 4, 5; ?plate 69, figures 5, 6

Holotype.—GSM 13995, the original of Portlock, 1843, plate I, figure 1a, 1b. This specimen and the other remopleuridid material described by Portlock (1843, pp. 254–

257, 470; pl. I, figs. 1–6; pl. XXIV, fig. 10) came from the Ordovician of Desertcreat parish, Co. Tyrone, N. Ireland. Some of the specimens are labelled as coming from Tirnaskea, and Fearnsides. Elles and Smith (1907, pp. 103, 119) believed that all Portlock's material came from the Killey Bridge beds, and the lithology of dark leaden-gray micaceous mudstones is in agreement with this. Trinucleid fragments on the blocks also support this view. The Killey Bridge beds occur below strata yielding *Dicellograptus complanatus*, and, as Stubblefield has remarked (1939, p. 60), a correlation with the Ashgillian (Upper Ordovician) may not be correct. Bancroft (1945, p. 182) regarded the highest part of the Caradoc series as including all or part of the *D. complanatus* zone. This would imply that the Killey Bridge beds are high Caradoc (Middle Ordovician) in age, and I am in agreement with this view. They contain raphiophorids, calymenids, cheirurids, *Cryptolithus*, *Dionide*, *Illaenus*, phacopids, *Remopleurides*, *Stygina*, and *Tretaspis*—a trilobite fauna which has some elements in common with the high Caradoc of Shropshire, and many elements in common with the lower Edinburg limestones of Virginia (Cooper and Cooper, 1946, pp. 83–85 etc.), of lower Middle Ordovician age.

Geological range.—Middle Ordovician.

Description.—The cephalon is subsemicircular in outline, convex. The glabella is transversely oval in outline, moderately convex, the anterior tongue of width about half the maximum width and bent vertically down immediately in front of the eyes, two pairs of glabellar furrows faintly marked; the basal pair commencing a short distance inside the margin at two-thirds the length and curving inwards and backwards to a point about one-third the width; the second pair commencing inside the margin at one-third the length and curving less sharply inwards and backwards and extending slightly further in. The palpebral furrows are deep, continuous with the lateral tongue furrows and run into the occipital furrow. There appears to be no furrow at the anterior margin of the tongue. The palpebral lobes are narrow. The occipital furrow is deep, the occipital ring long (sag.), becoming shorter laterally, convex. The eyes are most strongly curved posteriorly, and extend from the anterolateral margin to the outer part of the occipital ring; the lenses are numerous, small, and arranged in vertical lines (pl. 70, fig. 5). The free cheeks are triangular, the maximum width at the posterior margin, narrowing and disappearing forwards, the genal spine long and broad. The posterior branch of the facial suture cuts the posterior margin close to the occipital ring; the anterior branch circumscribes the tongue and presumably is continued across the doublure by a single median suture.

The hypostome (pl. 70, fig. 2) is transversely rectangular in outline, gently convex, the middle body semicircular in outline, defined by deep furrows. The narrow anterior border is extended into long anterior wings pointing directly outwards. The lateral and posterior borders are narrow, but become broader posterolaterally to form the square corners. In front of these corners a broad shallow notch occurs in the lateral borders. The middle body is without middle furrows, and anteromedially is raised in a low boss. Two large oval areas extending diagonally inwards from the anterolateral corner to the middle line are ornamented with very fine terrace lines running longitudinally; the remaining anteromedial area is triangular and ornamented with coarse terrace lines converging backwards.

Thorax of 11 segments, the axis broad (tr.) two-thirds the total width, convex. The pleurae are narrow (tr.), down-bent, the anterolateral corner rounded, the posterolateral corner drawn out into a short spine; the inner anterior corner (pl. 70, fig. 4) is drawn up into a large boss which fits into an articulating socket in the previous segment (or the posterior border of the cranidium); the pleural furrows commence just inside the articulating boss, run diagonally outwards, and become shallower. The doublure is extended inwards to the axial furrows. ?The pleurae of the seventh segment with a longer spine than the remainder. The axial ring of the eighth segment with a median spine.

The pygidium with a convex axis, short, rounded; the first axial ring narrow medially, expanding laterally into two large lobes, inside these lobes the remainder of the axis

is divided by a median longitudinal furrow into two inner lobes. The side lobes are flattened, sloping downwards and outwards, the posterolateral margin with two pairs of short spines. The doublure is broad and extends inwards to the margin of the axis.

The ornament is of very fine tubercles on the free cheeks and the glabella, a coarser tuberculate ornament on the occipital ring and the axial rings of the thorax and pygidium, with the largest tubercles along the posterior margin of the rings (pl. 70, fig. 4). A terrace line ornament runs transversely across the dorsal surface of the thorax, on the doublure in all parts the terrace lines run parallel to the margins, and hence longitudinally on the doublure of the thoracic pleurae.

Discussion.—Salter (1853 B) redescribed most of Portlock's material together with additional specimens from Tramore, Co. Waterford, Eire. He thought that Portlock's *Remopleurides colbii*, *R. laterispinifer*, and *R. dorsospinifer* were probably all one species, and the presence or absence of longer pleural spines on the seventh segment, and a median spine on the eighth segment, were associated with sexual differences. I am inclined to suggest a somewhat different interpretation of the material. GSM 35553 (Portlock, pl. I, fig. 2a; Salter, pl. VIII, fig. 2), the type of *R. laterispinifer*, may represent the same species as the genotype. The latter does not have the longer pleural spines on the seventh segment seen in this specimen. No axial spine is seen on the eighth segment of 35553, but it is an internal mould and little trace of the spine is to be expected. The diplotype, in which the exoskeleton is preserved as a thin light-colored layer, has the median part of the eighth segment broken. Thus we do not know whether or not the genotype had a median spine on the eighth segment, and it did not have longer pleural spines on the seventh segment. The presence of these latter spines on GSM 35553 is the only feature which distinguishes it from the genotype, and if it does belong to the same species then this difference may be an example of sexual dimorphism. GSM 35554 (not figured, a cranidium) and 35562, the hypostome (Portlock, pl. XXIV, fig. 10, Salter, pl. VIII, fig. 5; and this paper pl. 70, fig. 2) probably also belong to *R. colbii*.

R.? dorsospinifer Portlock (holotype GSM 13996, Portlock, pl. I, fig. 3a; Salter, pl. VIII, fig. 3; this paper pl. 69, figs. 7, 8) I consider is at least specifically distinct from *R. colbii*. Salter (p. 6) noted that it was a proportionately narrower form, and in addition to the long median spine on the eighth thoracic segment, it has a proportionately narrower glabellar tongue and the free cheeks are wider anteriorly. GSM 13997 (pl. 69, figs. 9, 10), 13998, 13999 probably also belong to this species. A third species is represented by *R. longicostatus* (holotype GSM 35559, Portlock, pl. I, fig. 6; this paper, pl. 70, fig. 3), and I think that this species may be placed in the same genus as *R. colbii*. Portlock's *R. longicapitatus* (holotype GSM 7777, Portlock, pl. I, fig. 5; this paper, pl. 70, fig. 6) is, as Salter believed (p. 9) a cranidium of *R. longicostatus*, and a third unfigured specimen (GSM 7778) also belongs here.

It will thus be seen that I regard Portlock's original material as including at least three distinct species, *Remopleurides colbii*, *R. longicostatus*, and *R.? dorsospinifer*, and the latter of these may represent a separate genus. I hold this view, which differs somewhat from Salter's, partly as a result of studying silicified remopleuridids from the Edinburg limestones of Virginia. These include at least three species, remarkably similar to Portlock's, and the morphology is revealed in great detail. It is intended to discuss the question further when the silicified trilobites are described. I agree with Salter (p. 2) in assigning the hypostome from Tyrone to *R. colbii*, both because of its size and because a similar hypostome belongs to a similar species from Virginia.

The genera of the family Remopleurididae have been discussed by Warburg (1925, pp. 79–82, etc) and by Raymond (1925, pp. 55–56). The latter author gives a brief diagnosis of *Remopleurides*, including the sentence "Hypostoma bifurcated, with very long forks." This statement is based upon the hypostome of "*Remopleurides*" *striatulus* Walcott (Raymond, 1925, pp. 57–58, pl. 3, figs. 4, 5). I have seen the type specimens and one of them (MCZ No. 1618) has the hypostome apparently in position, and extending back far beyond the posterior margin of the cephalon. The hypostome and other features differentiate this species from

Remopleurides colbii, and there seems no doubt but that it represents a new genus, with a hypostome of unique size among trilobites, so far as is known.

Genus ROBERGIA Wiman, 1905

Genotype.—By monotypy, *Remopleurides micropthalmus* Linnarsson, 1875.

ROBERGIA MICROPTHALMUS (Linnarsson, 1875)

Plate 71, figures 1–8

Holotype.—SGU, a broken and incomplete cranidium, the original of Linnarsson, 1875, pl. 22, fig. 3, from Önsveds-bäcken, Jemtland, Sweden. Dr. P. Thorslund informs me (personal communication) that at this locality there are outcrops of the *Ogygiocaris* shales. Material in the museum of the Geological Survey of Sweden suggests that at Önsveds-bäcken *Robergia* occurs in the lower part of the *Ogygiocaris* shales. Dr. Thorslund has collected *Robergia* from these same beds on the islands of Frösön and Andersön, respectively 15 km. N.N.E. and 9 km. N. of Önsved. The Ogygiocaris shales include the zones of *Climacograptus putillus* below and *Nemagraptus gracilis* above (cf. Thorslund 1940, pp. 9, 105, etc.). Hadding (1913, pp. 28, 89) records *Robergia micropthalmus* from both zones.

As Thorslund has pointed out (1940, p. 105, footnote 2), *Climacograptus putillus* described by Hadding is probably not identical with *C. putillus* (Hall). It occurs in association with *Glyptograptus teretiusculus* and *Dicellograptus* sp.

Other material.—Further cranidia, the free cheeks, and pygidia, from the type locality, described by Holm (1897), SGU, and Wiman (1905), PU Ar. 1037 to 1040 inclusive; from the same beds on the island of Andersön in Lake Storsjön, Jemtland, described by Hadding (1913), PL LO 2556t–2559t inclusive.

Geological range.—Uppermost Lower Ordovician (upper Llandeilo) and lower Middle Ordovician.

Description.—The maximum width of the cranidium is across the palpebral lobes, and is about equal to the length. The anterior tongue expands forward, is convex and bent steeply down so that the anterior margin is vertical. The posterior half of the cranidium is flattened, with three pairs of glabellar furrows all commencing a short distance inside the palpebral furrow; the first deepest, course convex forwards, extending inwards to about one-third the width, the ends connected by shallow depressions to the posterior end of the palpebral and the occipital furrows; the second larger and shallower, course similar, situated opposite the mid-point of the eyes; the third shallow, straight, running diagonally inwards, the outer ends opposite the anterior end of the eyes. The occipital furrow is deepest laterally, the occipital ring moderately convex. A furrow circumscribes the glabellar tongue and is continuous with the palpebral furrow and the axial furrow behind the eyes. A narrow flat border runs outside this furrow around the tongue, and is horizontal along the anterior margin. The palpebral lobes are narrow, flat, and crescentic in outline. The posterior portion of the fixed cheeks and the posterior border are flattened, and extend out to a width almost equal to the maximum width of the cranidium.

The free cheeks (pl. 71, fig. 1) are narrow, with convex lateral and posterior borders. The posterior margin curves forward from the suture line, and the genal angle is situated opposite a point about two-thirds the length of the eye. The genal spine is long, circular in cross section, and continues the line of the lateral border. A narrow concave area separates the borders from the vertical eye surface. The lenses are small and arranged in vertical lines (pl. 71, fig. 5). A narrow doublure extends forward from the anterolateral border, and must underlie the flat border of the anterior tongue of the cranidium.

The pygidium is subquadrangular in outline, the length equal to the width. The axis tapers backwards, is moderately convex, shows five or more axial rings, and does not reach to the posterior margin. The side lobes slope gently posterolaterally, most steeply posteriorly. The rib furrows are low, broad, the first two pairs running out and back towards the first two pairs of marginal spines. The posterior margin is gently arcuate, with three pairs of short spines. The doublure is broad and extends inwards to a line joining the anterolateral corners of the pygidium to the posterior end of the

axis, and is ornamented with terrace lines subparallel to the margins.

Discussion.—The thorax and hypostome of *Robergia* are not known from Sweden. Comparing the cranidium and pygidium, it seems that *Robergia* is represented in the Balclatchie of Scotland by *R. barrandei* (Reed, 1903, pp. 30–33, pl. IV, fig. 9, pl. V, figs. 1–4; 1931, pp. 7–8), in the Athens of Saltville, Va, by *R. major* (Raymond, 1925, pp. 60–61, pl. 3, figs. 6–10). The thorax of *R. major* is described and illustrated, and the hypostome described (but not illustrated) as "bifurcated, with two very long prongs." Raymond's diagnosis of *Robergia* (1925, p. 56) is evidently based in part on *R. major*, but we do not know that the genotype has a forked hypostome.

Robergia differs from *Remopleurides* in that the eyes are proportionately shorter, and the anterior tongue of the glabella therefore larger, being nearly equal in size to the remainder of the glabella, and having a flat anterior border. The glabellar furrows are more deeply impressed in *Robergia*, and there are three pairs. The pygidium has a proportionately longer axis, extending back to near the posterior margin.

Family Scutellidae R. and E. Richter, 1925

Genus Bronteopsis Nicholson and Etheridge, 1879

Bronteopsis Salter, 1866, p. 143, nomen nudum.

Genotype.—By monotypy, *Bronteopsis scotica* Nicholson and Etheridge, 1879.

Bronteopsis scotica Nicholson and Etheridge, 1879

Plate 71, figures 9–12; text-figure 4

Lectotype (here selected).—BM In 22695, an internal mould, the original of Nicholson and Etheridge, pl. X, fig. 21 (see also Reed, 1904, pl. XIII, fig. 11), from the Balclatchie beds of Balclatchie, Girvan, Ayrshire, Scotland.

Other material.—BM (Gray Collection), In 22686–88 and 22690–97 inclusive, 22703, the material figured by Nicholson and Etheridge (1879, pl. X, fig. 21; pl. XI, figs. 1–3, 5) and by Reed (1904, pl. XIII, figs. 5–13; 1914, pl. IV, fig. 6); In 22689, 22698–9, 36995–6. No good specimens occur in later parts of the Gray Collection.

Geological range.—Lower Middle Ordovician.

Description.—The cephalon is transversely subsemicircular in outline, the genal angles drawn out posterolaterally into long points. The glabella is contracted to the least width at the first glabellar furrows, then expands forwards to the maximum width; gently convex transversely, the posterior part (in front of the occipital furrow) bluntly ridged, strongly convex longitudinally; three pairs of glabellar furrows are represented by shallow pits placed at three-quarters, one-half and one-third the length, respectively, the first largest, triangular in outline, the apex of the triangle directed outwards and merging into the axial furrow, the second and third circular in outline and situated about one-quarter the width at that point in from the axial furrows; the occipital furrow long (sag.), shallow; the occipital ring short (sag.), strongly convex. The axial furrows are broad and shallow in the posterior half, becoming weaker forwards and very faintly defining the anterior glabellar lobe. The cheeks are drawn out posterolaterally into broad flat genal points, the inner part strongly convex, with the eyes (situated close to the posterior border and at a distance apart equal to the maximum width of the glabella) at the highest point, the outer parts flattened, with the change of slope between these parts running from a point just in front of the third glabellar

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Explanation of Plate 70

Figs. *1, 2, 4, 5*—*Remopleurides colbii* Portlock. *1*, dorsal view of the holotype, original of Portlock, 1843, pl. 1, fig. 1a, ×4. Horizon and locality as pl. 69, fig. *5*, GSM 13995. *2*, ventral view of incomplete hypostome, internal mould, original of Portlock, 1843, pl. XXIV, fig. 10, ×6. Horizon and locality as pl. 69, fig. *5*, GSM 35562. *4*, part of thorax of same specimen as fig. *1*, ×10. *5*, part of eye surface of same specimen as fig. *1*, ×20. (p. 540)

3, 6—*Remopleurides longicostatus* Portlock. *3*, dorsal view of holotype, internal mould, original of Portlock, 1843, pl. I, fig. 6, ×2. Horizon and locality as pl. 69, fig. *5*, GSM 35559. *6*, dorsal view of cranidium, internal mould, original of *R. longicapitatus* Portlock, 1843, pl. I, fig. 5, ×2. Horizon and locality as pl. 69, fig. *5*, GSM 7777. (p. 542)

1

2

3

4

5

6

Whittington, *Remopleurides*

Whittington, *Robergia, Bronteopsis*

furrow back to the midpoint of the posterior margin. There is no preglabellar field. The eyes are semicircular in plan, the length about one-fifth the length of cephalon; the anterior branches of the suture running in a curve convex outwards to a point on the margin directly in front of the eye and united by a marginal rostral suture, the posterior branch of the suture curving to meet the posterior margin at about half the width of the cheeks. The posterior border is narrow, convex, and extends out as far as the posterior branch of the suture. The doublure of the cephalon (text-fig. 4B) is broad and convex ventrally. Under the cheeks it extends inwards as far as the change of slope between the inner and outer parts, anteriorly to a point in front of the third glabellar furrows. The connective sutures run inwards and backwards to isolate the rostrum. The hypostome (imperfectly preserved in one specimen, the lectotype, pl. 71, fig. 10) is wider than long, the maximum width being across the anterior wings. The anterior margin is convex forwards, and there is no anterior border. The anterior wings are large and rounded. The middle body is strongly convex, not subdivided and apparently without maculae. The lateral and posterior borders are flattened and the margins form a smooth curve.

The thorax of the lectotype shows eight segments, but the specimen is not complete. No specimens show more than this number of segments. The axial rings are moderately convex, the width about one-quarter the total width of the thorax. The pleurae with

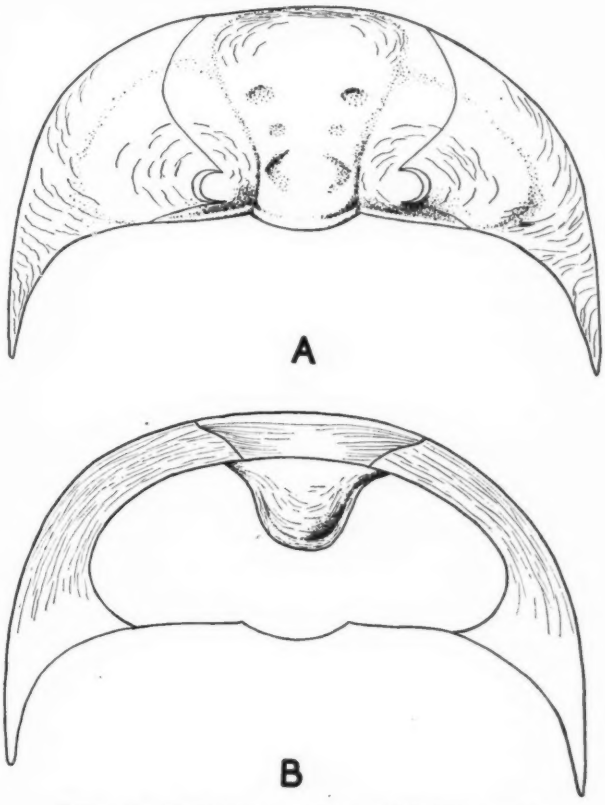

FIG. 4.—*Bronteopsis scotica* Nicholson and Etheridge. *4A*, dorsal view of the cephalon reconstructed from BM In 22698 (pl. *71*, figs. *11*, *12*) and In 22703 (pl. *71*, fig. *9*). c. ×2. *4B*, ventral view of the cephalon to show the doublure, rostrum and hypostome. Reconstructed using fig. *4A* and BM In 22695 (pl. *71*, fig. *10*). c. ×2.

EXPLANATION OF PLATE 71

FIGS. *1–8*.—*Robergia micropthalmus* (Linnarsson). *1*, dorsal view of free cheek, original of Holm, 1897, pl. 8, fig. 1, ×3. *Ogygiocaris* shales, Önsveds-bäcken, Jemtland, Sweden, SGU. *2*, *3*, *4*, dorsal, lateral and anterior views of a cranidium, original of Wiman, 1905, pl. V, fig. 2, ×5. Horizon and locality as fig. *1*, PU Ar. 1037. *5*, eye surface of same specimen as fig. *1*, ×20. *6*, dorsal view of holotype, original of Linnarsson, 1875, pl. 22, fig. 3, ×5. Horizon and locality as fig. *1*, SGU. *7*, external mould of pygidium, original of Hadding, 1913, pl. VIII, fig. 18, ×5. *Ogygiocaris* shales, Andersön, Jemtland, Sweden, PL. LO 2559t. *8*, external mould of pygidium, original of Wiman, 1905, pl. V, fig. 4, ×5. Horizon and locality as fig. *1*, PU Ar. 1039. (p. 543)

9–12—*Bronteopsis scotica* Nicholson and Etheridge. *9*, dorsal view of rubber cast of external mould of free cheek, original of Reed, 1914, pl. IV, fig. 6, ×3. Balclatchie beds, Balclatchie, Girvan, Ayrshire, Scotland, BM In 22703. *10*, dorsal view of the lectotype, internal mould, original of Nicholson and Etheridge, 1879, pl. X, fig. 21, ×2. Horizon and locality as fig. *9*, BM In 22695. *11*, *12*, counterpart moulds of an incomplete individual, ×2. Horizon and locality as fig. *9*, BM In 22698. (p. 544)

the fulcrum at about two-thirds the width, the outer parts bent gently down and drawn out into backwardly directed points; a narrow (exs.) convex anterior band and a narrow (exs.) concave posterior band, extending out to the fulcrum, between these bands the central part is raised in a ridge, the crest of which is nearer to the posterior margin and slopes most steeply posteriorly.

The pygidium is subsemicircular in outline, the length more than half the width, gently convex with a very faintly concave border. The axis is of width about one-seventh the total width, and reaches back to about half the length of the pygidium, bounded by broad shallow axial furrows, and continued posteriorly along the axial line by the post-axial ridge which dies out as the border is approached; the rounded termination of the axis is demarcated by a sharp change of slope which merges into the post-axial ridge. The axial furrows are continued to the concave border of the pygidium by very shallow post-axial furrows; seven axial rings in the axis. The side lobes are gently convex, showing up to six pairs of ridges corresponding to those on the pleurae. The doublure is very broad, reaching inwards to the end of the axis.

The exoskeleton is ornamented with terrace lines, which on the glabella are parallel to the anterior margin, on the inner part of the cheeks are concentric around the eyes; on the outer part in curves convex posterolaterally. On the axial rings of the thorax the terrace lines are in curves convex forwards, on the doublure they are everywhere parallel to the margin, on the hypostome they run in curves parallel to the lateral and posterior margins.

Discussion.—The genus was erected and the genotype described by Nicholson and Etheridge (1879, pp. 166–169, pl. X, figs. 21, 22; pl. XI, figs. 1–5) and a redescription given by Reed (1904, pp. 94–95, pl. XIII, figs. 5–13; 1914, p. 26, pl. IV, fig. 6). In 1920 (pp. 282–283) and 1925 (pp. 66–69) Raymond placed *Bronteopsis* in the Styginidae, and Reed (1928, pp. 49, 76–77) accepted this view. Warburg (1925, pp. 93–96) also proposed the family Styginidae, but did not place *Bronteopsis* in it, regarding this genus as "more closely allied to *Bronteus* [*Scutellum*] than to *Stygina*." I am in agreement with this latter opinion, particularly after comparing and contrasting *Bronteopsis* and *Stygina* (see p. 547) and *Eobronteus* (Warburg, 1925, pp. 141–147, pl. III, figs. 5–15; Sinclair, 1949A), the oldest of the scutellids. A study of Sinclair's generic description and the plates shows that the cephalon of *Bronteopsis* is similar to that of *Eobronteus*. That of the former is distinguished particularly by the glabellar furrows, the anterior branch of the suture running more directly forwards, and the apparent absence of maculae on the hypostome. The two genera differ also in the characters of the thorax and pygidium. The number of segments in the thorax of *Bronteopsis* is at least eight (it is ten in *Eobronteus*), and the pleurae have the raised ridge and anterior convex and posterior concave borders, while in *Eobronteus* the pleurae are flat. The pygidium in *Bronteopsis* is wider than long, and the post-axial ridge is very faintly defined and has the median carina. In *Eobronteus* the pygidium is usually longer than wide, the axis less than half the length, and the post-axial ridge is clearly defined, features not seen in *Bronteopsis*. In both genera there are six pairs of pleural ribs, and the very long doublure. The terrace line ornament in *Eobronteus* and *Bronteopsis* is similar. It would seem that the two genera are closely related, and the distinctions between them not very great. *B. scotica* is the only species which I refer to the genus, and it is not completely known, and older than most species of *Eobronteus*.

Stygina is distinguished from *Bronteopsis* by the absence of glabellar furrows, smaller genal spines, the eyes closer together and the glabella narrower posteriorly, the flat pleurae, the pygidium with a larger axis and shorter convex doublure. I am in agreement with Warburg (1925, p. 96) that species like "*Bronteopsis*" *ardmillanensis* (Reed, 1904, pp. 92–94, pl. XIII, figs. 1–4; 1914, pp. 26–27, pl. IV, fig. 7) and "*B.*" *gregaria* (Raymond, 1920, pp. 283–284; 1925, pp. 69–70, pl. 3, figs. 12–14) are more closely allied to *Stygina* than to *Bronteopsis*, and I intend to discuss this subject further when describing silicified specimens of "*B.*" *gregaria*.

As noted above, I am not aware of any species other than the type that may be

referred to *Bronteopsis*. The genotype is from the Balclatchie beds of lower Middle Ordovician age (taking the *Nemagraptus gracilis* zone as the base of the Middle Ordovician). The Scotch species of *Eobronteus* is of a similar age, coming from the Craighead limestone series. Sinclair (1949c) has referred to the diversity of views on the age of the Craighead limestone series, but I consider that the work of Anderson and Pringle (1946) places beyond doubt the age as Middle Ordovician. The Irish species of *Eobronteus* is from the Middle Ordovician Killey Bridge Beds of the Pomeroy district, N. Ireland (see above, p. 541).

Family STYGINIDAE Vogdes, 1893

Trilobita with cephalon and pygidium moderately convex, subequal in size and semicircular in outline, the free cheeks prolonged beyond the rest of the cephalon as broad genal spines. The glabella poorly defined, narrow at base and expanding rapidly forwards. Eyes situated at inner posterior corners of cheeks. Sutures opisthoparian, anterior branches diverging out to the anterior margin, along which they are united by the rostral suture. Doublure broad, rostrum isolated by connective sutures. Hypostome shield-shaped, middle body convex, undivided, lateral and posterior borders flattened.

Thorax of nine segments. Pleurae flat, fulcrum at half width, outside which the pleurae are bent gently down. Pygidium with axis defined laterally but not posteriorly, weakly segmented, side lobes without ribs and furrows, doublure broad.

Geological range.—Lower to Upper Ordovician.

Discussion.—Raymond (1920, pp. 282–283) included within this family three genera—*Stygina*, *Bronteopsis* and *Raymondaspis* (= *Holometopus*). For the reasons given below I consider that the name *Raymondaspis* should not be used at present, and I regard *Bronteopsis* as belonging within the Scutellidae. *Phillipsinella* has in the past been placed in the Styginidae, but, following a reinvestigation of the ventral exoskeleton, I consider that it is the representative of a new and distinct family (see below, p. 559). The Styginidae thus includes trilobites of the type of *Stygina latifrons* and species which have been referred to "*Bronteopsis*" or "*Holometopus*," e.g. "*B.*" *ardmillanensis* Reed, "*B.*" *gregaria* Raymond, and *Stygina? nitens* (Thorslund, 1940, pp. 137–139, pl. 6, figs. 1–10). A recent addition is the genus *Protostygina* Prantl and Přibyl, 1948 (pp. 9–13, pl. II, fig. 2, pl. III, fig. 1, text-fig. 6). Lower Ordovician trilobites in North America have also been placed in the Styginidae by Raymond (1924, pp. 430–431; 1937, p. 1102), including possibly the genus *Leptopilus*, though this latter form has a short parallel-sided glabella.

Richter (1932, p. 852–854) has placed the Illaenidae and Scutellidae within the superfamily Corynexochidea (= Bathyuriscidea, see R. and E. Richter, 1941, p. 35), remarking on the similarity of the rostrum, hypostome, and number of segments (ten) in the two families. The Styginidae resemble the Illaenidae and the Scutellidae in that the pygidium approximates the cephalon in size, the eyes are placed far back and the sutures opisthoparian, the doublure is wide, the rostrum and hypostome are similar in shape. I consider that the Styginidae should also be placed within the Corynexochidea.

Genus STYGINA Salter, 1853C

Genotype.—By subsequent designation of Raymond, 1920, p. 282, *Asaphus latifrons* Portlock, 1843.

STYGINA LATIFRONS (Portlock), 1843
Plate 72, figures 1–6, 9

Lectotype (here selected).—GSM 18991, an internal mould, the original of Portlock's plate VII, figure 6 (and Salter, 1866, pl. 18, fig. 7, fig. 10 in part), from the Killey Bridge beds of Pomeroy, Co. Tyrone, N. Ireland (Fearnsides, Elles and Smith, 1907, pp. 118–119). For a discussion of the age of these beds, see above, p. 541.

Other material.—From the type locality GSM 18994 (original of Portlocks' Pl. VII, fig. 5), GSM 18992 (original of Portlock's pl. VII, fig. 7, regarded by Portlock as a separate species, *Asaphus marginatus*, but placed by Salter [1864, pl. II, fig. 3 and p. 1; 1866, p. 172] in synonymy. This specimen does not show the hypostome as depicted by Salter in pl. II, fig. 3), GSM 18995, a small cranidium which has the elevated,

semicircular palpebral lobe preserved on the left, and the glabella outlined by shallow furrows, BM In 21672–73 (Lee Collection, original of Salter, 1866, pl. 18, fig. 8), BM In 21681.

The specimen figured by Salter (1866, pl. 18, fig. 9) showing the hypostome has not been traced in the collections of Oxford University Museum.

The specimens BM 59370, In 21682, 25924, 25926, apparently belong to this species, and come from Cynwyd, Merioneth, North Wales. As discussed elsewhere (Whittington, 1950, p. 42) these specimens probably come from the upper Ashgillian Dolhir beds of the crest slopes of Bwlch-y-gaseg, 2½ miles east by south of Cynwyd.

Geological range.—High Middle and Upper Ordovician.

Description.—The cephalon is semicircular in outline, moderately convex. The axial furrows at the posterior margin are separated by a distance equal to one-quarter the width of the cephalon, and run inwards and forwards to define the narrowest part of the glabella between the eyes, then curve to run outwards, but are very faint (or absent) in front of about half the cephalic length. The glabella when defined is widest anteriorly, the maximum width twice that of the occipital ring; the pre-glabellar furrow faint or absent; the glabella with the highest point at the midline of the occipital ring, without glabellar furrows, the occipital furrow broad (sag.) and shallow, crossing the glabella at the narrowest part. The eyes are situated close to the posterior margin and to the base of the glabella, and are elevated. The cheeks slope outwards and downwards from the eyes, with a concave border laterally; inside the eyes the cheeks slope steeply inwards, behind the eyes descending very steeply to the posterior margin. The anterior branches of the suture diverge outwards from the eyes, curving inwards at the anterior borders and joined along the anterior margin; the posterior branches are sigmoidal, cutting the posterior margin at half the width. The posterior border is not defined. The genal spines are short. The doublure is broad, convex ventrally, and ornamented with terrace lines; the rostrum defined by the connective sutures which run inwards and backwards across the doublure underneath the anterolateral corners of the cranidium. The hypostome is subtriangular in outline, with large anterior wings, the median part convex but the median body not defined by prominent furrows. The ornament is of terrace lines running longitudinally.

The thorax of nine segments. The axis is convex, about one-third the total width. The pleurae with the fulcrum at about half the width, the inner parts flat, the outer parts steeply sloping; no pleural furrows.

The pygidium is subsemicircular in outline, the length about equal to that of the cephalon, moderately convex. The axis is defined laterally by broad shallow furrows to about three-quarters of the length, not defined at the posterior tip, and possibly with a very faint post-axial ridge; some eight axial rings very faintly defined. The side lobes are convex, and descend steeply to the broad concave border. The doublure is broad, reaching inwards to the tip of the axis posteriorly, and to two-thirds the width of the facet anteriorly, convex ventrally, ornamented with terrace lines parallel to the margins.

Discussion.—The lectotype (pl. 72, figs. 1–3) is an internal mould with the eyes broken off, and part of the glabella broken anteriorly so that the doublure is revealed to the median line on the left side. The anterior branch of the dorsal suture can be seen curving forwards to the margin, and from where it meets the margin a curved fracture runs inwards and backwards across the doublure. I interpret this fracture as being at least approximately along the connective suture, and a suture in the same position is seen in the Girvan material (see below). The lectotype shows most of the features of the dorsal exoskeleton described above, except that the glabella is not defined anteriorly. The axis of the thorax shows that the articulating half-ring reaches forward almost to the articulating furrow of the next segment. The pygidial axis shows seven axial rings, and in the posterior half is depressed below the convex inner part of the pleural lobes. Other specimens do not have the axis depressed, but standing as high as the pleural lobe.

Reed (1904, pp. 50–51, pl. VII, fig. 10; 1914, pp. 18–19; pl. III, fig. 7; 1931, p. 11)

has described specimens (BM In 21605, 40931, 40960, etc.) from the Upper Ordovician Whitehouse group and the Starfish bed, Drummuck group, Girvan, Ayrshire, Scotland, which he referred to *Stygina latifrons*. The Scotch specimens are proportionately wider and more convex than the Irish form (compare pl. 72, figs. 7, 8, with figs. 2, 3) and are here called *Stygina latifrons* var. *scotica* var. nov. One of Reed's specimens showed the rostrum and hypostome, a second such specimen was described by Begg (1943, p. 58, pl. II, fig. 5; HM A 732), and a third is figured here (pl. 72, fig. 10).

The rostrum has the anterior and posterior margins curved forwards, the anterior most strongly. The hypostome is shield-shaped, the maximum width (across the tips of the anterior wings) being greater than the length. The anterior margin is curved to fit the posterior margin of the rostrum, and the large anterior wings are bent to slope steeply dorsally. The lateral margin is approximately in line with the connective sutures. The middle body is moderately convex, the anterior furrow absent, the lateral and posterior borders and middle furrow not preserved in this specimen. The ornament is of longitudinally directed terrace lines. which join posteriorly along curves parallel to the posterior margin. A deep pit is situated in the apex of the anterior wing. Begg has interpreted his specimen as showing broad shallow furrows separating the middle body from the anterior wings. After re-examining the specimen I consider that these furrows are the result of crushing in of the hypostome during preservation. Similar furrows are not seen in Reed's specimen or the one figured here, and the latter is in a far better state of preservation.

Salter (1853 C, p. 59; 1864, p. 2; 1866, p. 172) believed that the doublure of the cephalon of *Stygina* was not crossed by either a median or connective sutures. The Girvan specimens show clearly the connective sutures, and I interpret the lectotype as also revealing one of these sutures. Despite Reed's description of the rostrum in 1914, Raymond (1920, pp. 282–283; 1925, pp. 66–67) in discussing the family Styginidae made no reference to the ventral sutures. Warburg (1925, p. 93) repeated Salter's statement that the "Rostrum [was] large."

Genus Raymondaspis Přibyl, 1948

As pointed out by Raymond (1937, p. 1102) the name *Holometopus* is preoccupied (Milne-Edwards, 1853, p. 187). Raymond proposed the name *Warburgella* for Angelin's genus, but this name is preoccupied by *Warburgella* Reed (1931, pp. 14–15). Přibyl (in Prantl and Přibyl, 1948, p. 12) recently proposed the name *Raymondaspis*.

Genotype.—By subsequent designation of Miller, 1889, p. 550, *Holometopus limbatus* Angelin, 1854.

Raymondaspis limbatus
(Angelin, 1854)
Plate 72, figures 11–14

Discussion.—Dr. G. Regnéll, of the Natural History Museum, Stockholm, informs me that the holotype of *Raymondaspis limbatus* is probably lost. No topotype material is preserved in this museum or in the Geological Survey Museum, Stockholm. Through the kindness of Dr. J. E. Hede of the Palaeontological Institute, University of Lund, two topotype specimens of the pygidium of *R. limbatus* (collected by B. Lundgren and identified by J. C. Moberg) from the Lower Ordovician Orthoceratite limestone of Fågelsång, Scania, Sweden, have been sent to me. One specimen is an incomplete internal mould, the second shows the inner surface of the exoskeleton. This pygidium may be described as follows:

The outline is subsemicircular, the width being about twice the length, the height about one-third the length. The axis is narrow, moderately convex, defined laterally by broad, deep furrows, and reaches to about half the length, and is extended to the posterior margin by a narrower and lower post-axial ridge; the first axial ring only indicated. The side lobes are convex, steeply bent down laterally, the first pleural furrow only present, running just inside the anterior margin. The facets are large. The doublure is broad, and reaches inward as far as the termination of the axis.

This pygidium is not distinctive, and resembles that of later styginids, e.g. *Stygina ? nitens* (Thorslund, 1940, pl. 6, figs. 6–10). In view of this, and that the holotype is

probably lost, I do not think that the name *Raymondaspis* should be used until new and more complete material is available to show the characters of the genotype and to afford the basis for selection of a neotype.

Wiman (1906, pp. 293–294, pl. 29, figs. 21, 22) described a pygidium which he attributed to *Raymondaspis limbatus* obtained from boulders of red Orthoceras limestone from Borgehage, Öland, Sweden. I have examined this and other material from similar blocks collected by Wiman, which contain further pygidia and two incomplete cranidia. The cranidium is styginid in type, but does not resemble Angelin's plate 33, figure 7. The pygidium is similar in outline and convexity to the topotypes of *R. limbatus*, except that the duplicated border in Wiman's examples is concave, not convex and steeply sloping. It therefore seems that Wiman's material is not conspecific with *R. limbatus*.

Family ASAPHIDAE Burmeister, 1843
Genus HOMOTELUS Raymond, 1920

Genotype.—By original designation, *Homotelus ulrichi* Raymond, 1920.

HOMOTELUS ULRICHI Raymond, 1920
Plate 73, figures 3, 5, 6, 9, 10; text-figure 5

Lectotype.—MCZ 1576, the original of Raymond 1925, plate VI, figure 3, and selected as lectotype in the explanation of the plate. Exact horizon and locality unknown, but from the Upper Ordovician Eden shale in the vicinity of Cincinnati, Ohio.

Other material.—MCZ 1575 (the original of Raymond, 1925, pl. VI, figs. 4, 5), 3612, 3615–6, 3619–3620, 3622–3623, all from the same general locality.

Description.—The entire trilobite is suboval in outline, the width three-fifths of the length; the cephalon and pygidium are about equal in size; the width of the axis is half the width of the thorax, the axial area being gently convex, and the lateral areas bent steeply down.

The cephalon is subtriangular in outline, the width being about one and one-half times the length (exs.). The median part of the cephalon (including the glabella and much of the fixed cheeks) is gently convex, the lateral and anterior parts sloping steeply down to the border. This cephalic border consists of a narrow, steeply sloping outermost part which meets the doublure at a high angle; inside this steep edge the border is gently sloping, and widest in the free cheeks outside the eyes, dying out both towards the midline and the genal angles. The flattened inner part of the border is united by a curving surface to the steeply sloping outer parts of the cheeks. The form of the cephalon is shown in pl. 73, figs. 3, 5, 6. The posterior half of the glabella is outlined by the broad shallow axial furrows which, commencing at the posterior margin at a distance apart equal to half the cephalic width, curve inwards and forwards to die out in front of the mid-point of the cephalon, and about one-third the cephalic width apart. Text-figure 5 is a sketch of certain areas on the cranidium of MCZ 1575 where the shell appears lighter in color. These areas are roughly symmetrically arranged and may be areas of muscle attachment. However, no other specimen shows similar features. The "two pairs of pits between the eyes" noted by Raymond (1920, p. 287; 1925, p. 88) are faintly indicated on certain crushed specimens, but not on those retaining full convexity (e.g., pl. 73, figs. 5, 6). There is no occipital furrow, and I have not seen the median pustule described by Raymond. The eyes are large and stand high above the adjacent parts of the cephalon, and are situated far apart (the distance between them being greater than half the cephalic width) and at slightly less than half the cephalic length (exs.). The visual surfaces are curved and convex, and the palpebral lobes much shorter and narrower than these surfaces, so that the latter are directed upwards as well as forwards, outwards and backwards. The eye lenses are minute, numerous, and arranged in diagonal lines. The facial sutures are opisthoparian, the anterior branches running forwards in a curve convex outwards to meet the sharp angle of the border, then inwards along this angle and on to the steep outer part of the border, uniting at the midline on the anterior margin (see pl. 73, fig. 9). The unusual shape of the free cheeks has been described above. The genal angles are rounded. The cephalic doublure (pl. 73, fig. 10) is narrow laterally, becoming broad anteriorly, the breadth

(sag.) being one-third the cephalic length (sag.). Laterally the inner part of the doublure is flexed steeply dorsally. The doublure is crossed by the median suture (pl. 73, fig. 10). The hypostome is of length half the cephalic length (exs.), the width and length equal, a deep posterior notch, the base of the notch being at half the length. The middle body is not defined by furrows. The anterior margin is straight medially, laterally curving back, the anterior wings large and bent steeply dorsally. The lateral are broad and shallow, running from the inner anterior corner to the posterior border at the fulcrum.

The pygidium length is about two-thirds the width, gently convex. The width of the axis is less than half the pygidial width at the anterior margin, and it tapers back to the prominent termination at beyond half the pygidial length. The side lobes have large facets and the weak first furrows. The doublure is broad, reaching inwards to the tip of the axis, and convex ventrally.

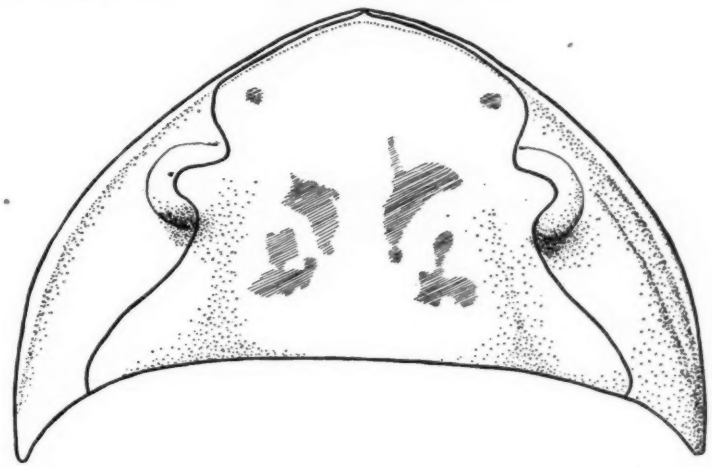

FIG. 5—*Homotelus ulrichi* Raymond. Dorsal view of the cephalon, drawn from MCZ 1575 (pl. 73, fig. 9). The areas shaded diagonally are those where the shell appears lighter in color. They may be areas of muscle attachment. ×2½.

margins run in a curve convex outwards to the posterior tip; the margins of the posterior notch are straight and converge forwards. Between the anterior margin and the base of the posterior notch the hypostome is flat, with a broad central depression. The posterolateral parts flanking the notch are bent gently dorsally. The hypostome is ornamented with terrace lines running subparallel to the lateral margins and the margins of the notch, but absent in the central area. At a point about one-third the length and beside the median depression the terrace lines diverge around a subcircular area which is the macula.

The thorax consists of eight segments. The axial furrows are very shallow. The pleurae are divided by the fulcrum into the inner flat half and the outer, steep portion. The facets are large. The pleural furrows

The borders of the cephalon, the facets of the thorax, and the doublure are ornamented with terrace lines subparallel to the margins, the borders of the pygidium having the terrace lines running inwards and backwards from the margin. The cranidium and the inner parts of the free cheeks, the axis and inner part of the side lobes of the thorax and pygidium are ornamented with fine scattered pustules.

Discussion.—The description is based on the lectotype and other material noted above, particularly MCZ 1575 and 3612A, which latter was prepared to reveal the hypostome. Many of the specimens, including the lectotype, are flattened, but four (MCZ 3612A–D) apparently retain the full convexity. The lectotype is of length 5.7 cm., but other specimens are larger, up to a maximum of circa 18 cm.

Raymond (1920, p. 286; 1925, p. 87) wrote, "*Homotelus* differs from *Isotelus* chiefly in lacking the concave borders on the shields." In *Isotelus gigas* (the genotype of *Isotelus*, see Raymond, 1914, and this paper, pl. 73, figs. 1, 2, 4) the anterolateral cephalic border consists of a steeply sloping outer part and an inner concave part. Towards the midline the angle between these parts becomes progressively less marked, but the anterior part of the profile along the midline remains concave (pl. 73, fig. 2). The anterolateral cephalic border in *Homotelus* is similar in form, but more strongly developed (pl. 73, figs. 3, 5, 6, 9) and the steep outer part continues to the midline. However, the anterior part of the profile in the midline is not concave (pl. 73, fig. 5). Thus the anterolateral cephalic border in the two genera is similar but the profile along the midline differs. The pygidium of *I. gigas* has a shallow concave border only behind the axis, and not laterally, and the same is true of *H. ulrichi* (see pl. 73, figs. 1, 2, 3, 5). Raymond's distinction between *Homotelus* and *Isotelus* seems therefore not to be valid.

Homotelus differs from *Isotelus* in that it is a proportionately broader form, has the eyes placed farther forward, and has an ornament of fine pustules, not the characteristic small, closely-spaced pits of *I. gigas*. The hypostomes of the two genera are closely comparable. The differences betweeen the two forms are thus small, and it is doubtful if they should be ranked as separate genera. I consider that if the name *Homotelus* is retained it should be used at present only for the genotype, and that it is probable that many of the species referred to this genus by Raymond (1920, pp. 288–292; 1925, pp. 88–95) do not belong here.

Family RAPHIOPHORIDAE Angelin, 1854

Trilobita with subtriangular cephalon and pygidium, narrow axis. Glabella expanding forward and strongly convex, frequently drawn out into a long frontal spine; occipital ring convex, three or four pairs of ovate muscle scars sometimes present, the posterior pair situated at the ends of the occipital furrow. Triangular, convex alae present in the young stages and in some adults. Cheeks triangular, convex. Eyes absent. Facial sutures opisthoparian, running in a curved path along the outer part of the cheeks, and united along the anterior margin of the cephalon. Doublure narrow, not crossed by median or connective sutures, and thus uniting the free cheeks. Genal spines long.

Thorax of five or six segments, the first frequently longer than the remainder. Pleurae horizontal, tips bent down, strong pleural furrows. Pygidium with broad vertical border, axis well defined and extending to posterior margin, many ring furrows. Side lobes with one or many pleural furrows.

Geological range.—Lower Ordovician to middle Silurian.

Discussion.—In his original definition of this family Angelin (1854, pp. 79–80) included the genera *Lonchodomas*, *Ampyx* and *Raphiophorus*. Redescriptions of the

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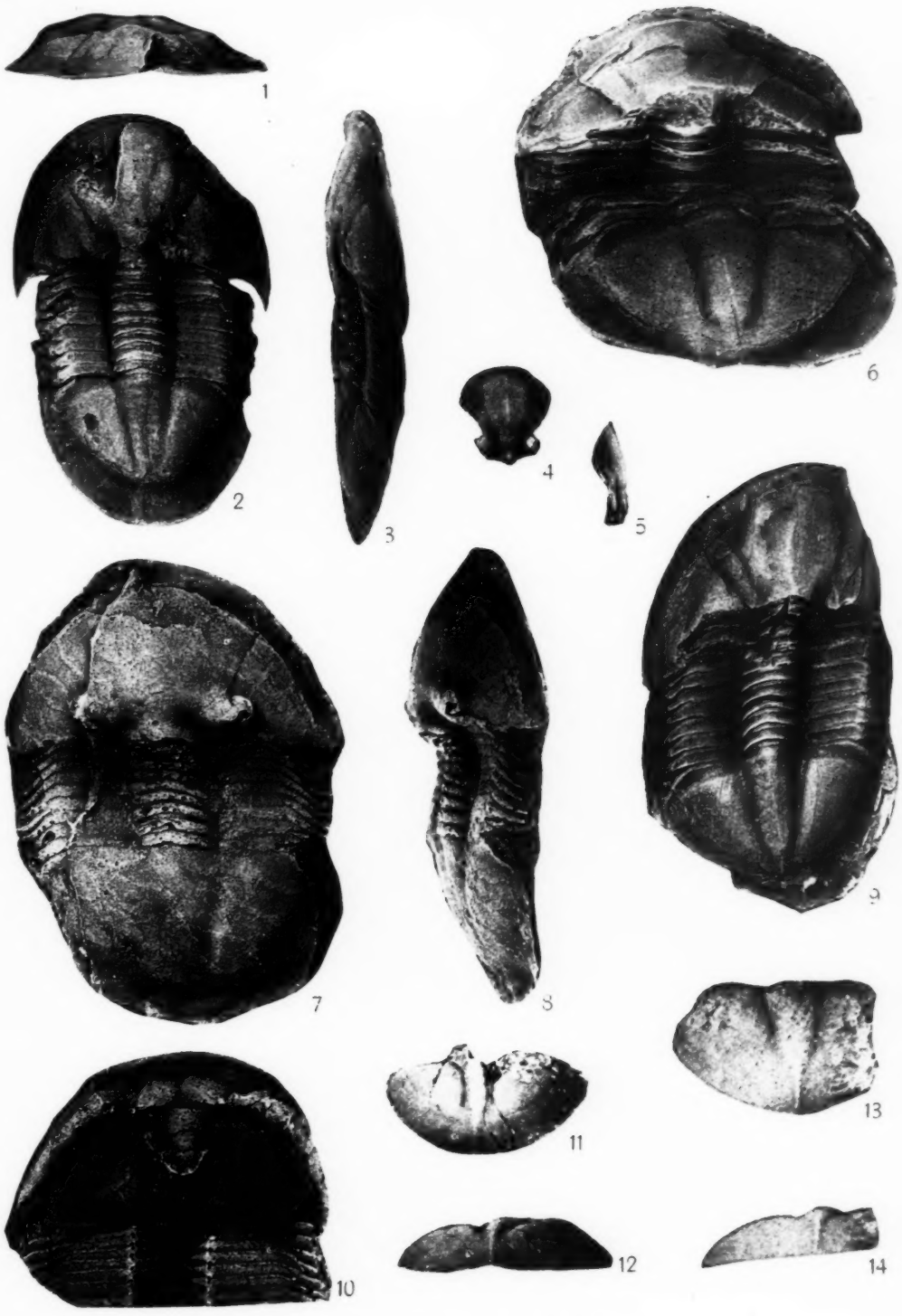
EXPLANATION OF PLATE 72

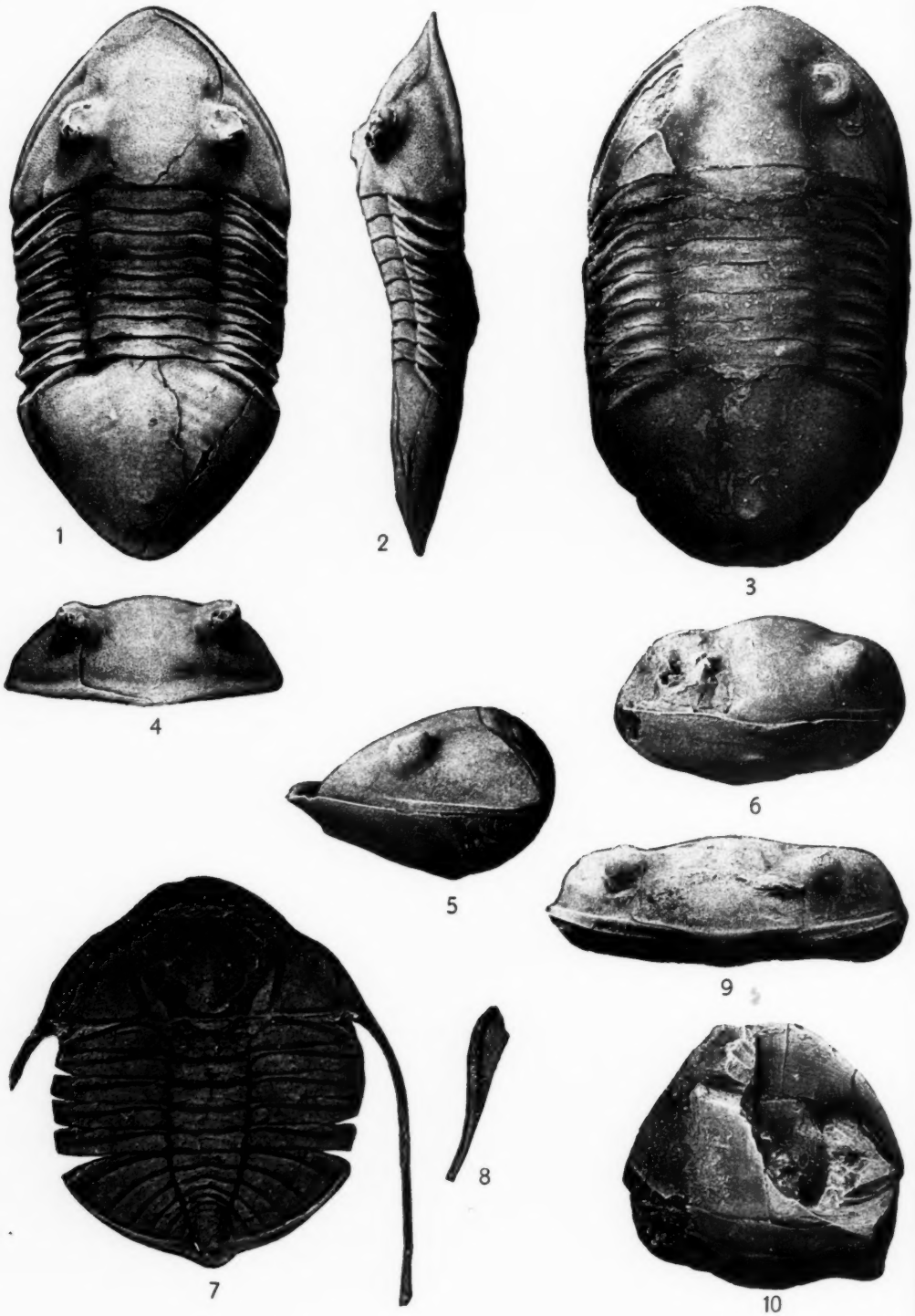
FIGS. *1–6, 9—Stygina latifrons* (Portlock). *1, 2, 3*, anterior, dorsal and lateral views of the lectotype, an internal mould, original of Portlock, 1843, pl. VII, fig. 6, ×2. Killey Bridge beds, Pomeroy, Co. Tyrone, Northern Ireland, GSM 18991. *4, 5*, dorsal and lateral views of a cranidium, internal mould, ×2. Horizon and locality as fig. *1*, GSM 18995. *6*, dorsal view, internal mould, original of Portlock, 1843, pl. VII, fig. 7, ×2. Horizon and locality as fig. *1*, GSM 18992. *9*, dorsal view, internal mould, original of Portlock, 1843, pl. VII, fig. 5, ×2. Horizon and locality as fig. *1*, SM 18994. (p. 547)

7, 8, 10—Stygina latifrons var. *scotica* Whittington, var. nov. *7, 8*, dorsal and lateral views of rubber cast from external mould, ×2. Starfish bed, upper Drummuck Group, Thraive Glen, Girvan, Ayrshire, Scotland, BM In 21605. *10*, ventral view of rubber cast from counterpart internal mould, to show the rostrum and hypostome, ×2. Horizon and locality as fig. *7*, BM In 21605. (p. 549)

11–14—Raymondaspis limbatus (Angelin). *11, 12*, dorsal and posterior views of internal mould of pygidium, ×2. Orthoceratite limestone, Fågelsång, Scania, Sweden, PL 1599A. *13, 14*, dorsal and posterior views of a plasticine mould of the inner surface of the pygidium, ×6. Horizon and locality as fig. *11*, PL 1599. (p. 549)



Whittington, *Stygina*, *Raymondaspis*



Whittington, *Isotelus, Homotelus, Ampyxina*

first two of these genera are given below, and a fairly complete understanding of the characters is possible. The diplotype of *Raphiophorus* is, however, an unsatisfactory specimen as a basis for a genus (see below) and I do not think that this name should be used at present for species other than the genotype. I have continued to use Angelin's family name, however, rather than the later name Ampyxidae Chapman, 1890.

I have included within this family *Ampyxina* and *Raymondella*, for the reasons given below. Raymond (1937, pp. 1082–83) referred with doubt his Lower Ordovician genus *Diplozyga* to the Raphiophoridae, but the cephalon of this form is unknown. Alae are present in the young stages of silicified specimens of *Ampyx* from the Edinburg limestones of Virginia.

Richter (1932, pp. 854–855; see also Stubblefield, 1936, p. 436) placed the Raphiophoridae with the Trinucleidae in the superfamily Cryptolithidea. To the characters which these families have in common may be added that of the muscle-scar pattern in the axial region of the dorsal exoskeleton (see below).

Genus RAPHIOPHORUS Angelin, 1854

Genotype.—By subsequent designation of Raymond, 1925, p. 30, *Raphiophorus setirostris* Angelin, 1854.

RAPHIOPHORUS SETIROSTRIS
Angelin, 1854
Plate 74, figures 1–2

Holotype.—RS Ar. 9248 with 9248a, the counterpart external mould, the original of Angelin 1854, plate XL, figure 6, from the Black *Tretaspis* shale of Draggå bro, Dalarna, Sweden. There is another fragment, number Ar. 9249, kept in the same tray, on which is a poorly preserved cranidium (with punctate shell) and a pygidium, apparently belonging to *Lonchodomas* and thus not conspecific with *R. setirostris*. Angelin gives the horizon of his species as Da*?*, by which he meant rocks now called the *Chasmops* Series. Dr. G. Regnéll informs me (personal communication) that he believes this to be a misprint for Db or Db*?*, since on page VI Angelin states that the black shales found at Draggå (the type locality of *R. setirostris*) and other localities in Dalarna belong to Db, now called the *Tretaspis* Series. Törnquist (1884, p. 89) states that *R. setirostris* is found, according to Angelin, in black *Trinucleus* shales on Draggå Rivulet. Dr. Regnéll further points out that all statements on the Draggå Rivulet agree in refering the series of strata exposed (or formerly exposed) there as the *Trinucleus* shale (= *Tretaspis* shale).

The *Tretaspis* shales belong to the zone of *Pleurograptus linearis* and *Climacograptus styloideus* (Henningsmoen 1948, p. 375, 425–426), and are equivalent to the upper part of the Caradoc of Shropshire, England.

Discussion.—The holotype is a small individual (ca. 6.0 mm. in length excluding the spines) with five segments, but the cephalon is crushed, and the course of the facial suture and nature of the free cheeks cannot be observed. The frontal spine is circular in section and longer than the rest of the glabella. The latter is oval in outline, and

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EXPLANATION OF PLATE 73

FIGS. *1, 2, 4*—*Isotelus gigas* Dekay. Dorsal, lateral and anterior views, original of Raymond, 1914, pl. 3, fig. 3, ×1½. Trenton Limestone, Trenton Falls, New York, MCZ 41. (p. 552)

3, 5, 6, 9, 10—*Homotelus ulrichi* Raymond. *3*, dorsal view of the lectotype, original of Raymond, 1925, pl. 6, Fig. 3, ×1½. Eden group, near Cincinnati, Ohio, MCZ 1576. *5, 6*, lateral and anterior views of an enrolled specimen, ×1½. Horizon and locality as fig. *3*, MCZ 3612 B. *9*, anterior view of an enrolled specimen, original of Raymond, 1925, pl. 6, figs. 4, 5, ×1½. Horizon and locality as fig. *3*, MCZ 1575. *10*, ventral view of an enrolled specimen which has been prepared to reveal part of the hypostome, ×1½. Horizon and locality as fig. *3*, MCZ 3612 A. (p. 550)

7, 8—*Ampyxina bellatula* (Savage). *7*, dorsal view, internal mould, ×6. Thebes sandstone, southwest quarter section 29, T. 11 S, R. 2 W, Hardin Quadrangle, Illinois, USNM. *8*, dorsal view of free cheek, internal mould, ×6. Horizon and locality as fig. 7, USNM. (p. 557)

there is a depressed triangular area between the posterolateral margin of the glabella and the inner slope of the cheeks. Part of this area probably represents the ala. The genal spines are circular in section, with a groove on the dorsal and ventral sides, long and gently curved, reaching back far beyond the pygidium. The thorax contains five segments, the first segment being markedly longer than the rest. The pygidium is transverse with a broad, sloping border. Two axial rings are seen on the axis, and the pleural furrow of the first segment runs outwards and backwards.

The rounded section of the frontal glabellar spine and other features exclude this form from *Lonchodomas*, and the five segments of the thorax and very short pygidium distinguish it from the genotype of *Ampyx*. The holotype resembles the specimens from the Upper Ordovician *Trinucleus* shales figured as "*Ampyx*" *tenellus* Barrande by Olin (1906, pl. IV, figs. 11–12), and also Barrande's original figures (1872, p. 50, pl. II, figs. 28–30) of specimens from the Upper Ordovician of Bohemia. Since the holotype of *Raphiophorus setirostris* does not show the course of the facial suture and other characters, a full description cannot be given until further material is collected from the type locality. In the meantime I suggest that the name should only be used for the genotype.

Genus AMPYX Dalman, 1827

Genotype.—By monotypy, *Ampyx nasutus* Dalman, 1827.

AMPYX NASUTUS Dalman, 1827

Plate 74, figures 3–9; text-figures 6A, B

Neotype (here selected).—RS Ar. 13394. Dr. G. Regnéll informs me (personal communication) that the holotype of *Ampyx nasutus* Dalman (1827, pp. 253, 279, pl. V, figs. 3a–c) is either not preserved or cannot be identified in the collection of the Swedish State Museum. Dalman listed more than one locality for his species, without indicating one as type. From the first, Skarpåsen, no material is available in the Swedish State Museum. From the second, Västanå (referred to as Husbyfjöl by Dalman), Östergötland, Sweden, abundant material is available, and the neotype has been selected from this. It comes from the *Asaphus* limestone of upper Arenig (Lower Ordovician) age.

Geological range.—The geological range of this genus has been given as Ordovician to Silurian, since raphiophorids occur, for example, in the Middle Silurian of England (the lower Ludlow) and Bohemia. Species which I regard as belonging to this genus occur in the Llanvirn and Llandeilo, e.g., *Ampyx mammilatus* Sars, 1835, and varieties (Størmer, 1940; Whittard, 1940), and in the lower Middle Ordovician of Virginia. I have not seen any Upper Ordovician or later raphiophorid which I regard as certainly representing the genus *Ampyx*. I therefore consider that the range is Lower and Middle Ordovician.

Description.—The cephalon is subtriangular in outline, the width about twice the sagittal length (excluding the frontal spine). The glabella is pear-shaped, expanding forwards, strongly convex, the anterior portion drawn upwards and forwards into a long curved spine, circular in cross section; three pairs of muscle scars (pl. 74, figs. 3, 4, text-fig. 6A) are situated adjacent to the axial furrows, the first subcircular in outline and just in front of the occipital furrow, the second the largest, ovate, the third the smallest, circular, situated a short distance behind the greatest width; the occipital furrow is broad (sag.) and shallow, with a pair of ovate muscle scars situated at the outer ends; the occipital ring is convex, not separated by the axial furrow from the posterior border. The anterior border is separated from the glabella by a shallow preglabellar furrow, continuous with the axial furrows which are also shallow, with the deep, elongate anterior pits (*a* in text-fig. 6A) situated opposite the greatest width of the glabella. The cheeks are convex, the inner parts sloping gently outwards and forwards, the outer parts steeply sloping or vertical, meeting the narrow, gently sloping borders at a sharp angle. Eyes are absent. The suture line is marginal anteriorly, crossing the cheeks in a curve concave outwards, at the genal angle turning sharply inwards and backwards to cross the posterior border. The cephalic doublure (pl. 74, figs. 6, 7) is narrow, and subdivided into an outer flat part and an inner portion convex ventrally.

The doublure is not crossed by sutures. The genal spines are long, curved, and circular in cross section. The posterior marginal furrow is shallow, with a deep pit (*p* in text-fig. 6A) situated just inside the suture line. The posterior border is convex.

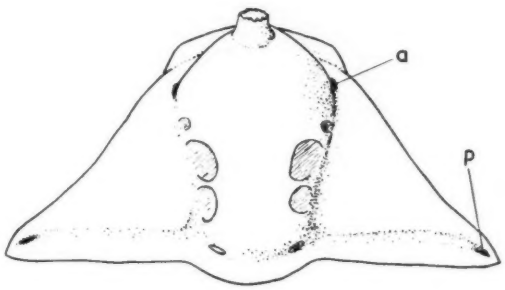
The hypostome is unknown.

The thorax is of six segments. The axial ring is gently convex, the articulating furrow with paired muscle scars. The axial furrows are very shallow. The pleurae are horizontally extended, bent down vertically at the extremities. The pleural furrow is shallow, deepening outwards, and in the last three segments curving forwards at the outer ends.

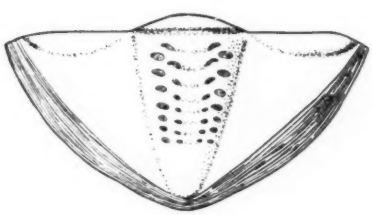
The pygidium is triangular in outline, the width twice the length. The axis is convex, rounded posteriorly, with double rows of muscle scars (pl. 74, fig. 9, text-fig. 6B), the outer pairs ovate, the inner pairs smaller, elongated, lying in faint furrows. The outer rows appear to correspond in position with the appendifers of the thorax. The side lobes are gently convex, the borders bent steeply down, wide laterally, narrowing posteriorly to the midline. One pair of pleural furrows curving forwards and becoming deeper outwards.

A fine punctate ornament occurs on the dorsal surface of the exoskeleton, and terrace lines on the vertical borders of the thorax and pygidium, and on the doublure.

Discussion.—The pattern of the muscle scars on the glabella and axis of the pygidium of *Ampyx* resemble closely those of *Trinucleus* and *Tretaspis* respectively (Størmer, 1930, pp. 93–96, figs. 38, 39), except that the pygidium of *Ampyx* shows the faint inner pairs of scars which are not seen in *Tretaspis*. The muscle scars on the pygidium of *Ampyx* and *Lonchodomas* (pl. 74, figs. 9, 15, text-fig. 6B, 7B) are similar to each other. As in Størmer's material, the scars appear as smooth areas darker in color.



A



B

FIG. 6—*Ampyx nasutus* Dalman. *6A*, dorsal view of the cranidium, drawn from RS Ar 13400 (pl. *74*, fig. *3*). The muscle-scars are diagonally shaded. a, anterior pit; p, pit at extremity of posterior marginal furrow. ×2⅔.

6B, dorsal view of the pygidium, drawn from RS Ar 13398 (pl. *74*, fig. *9*). The muscle scars are diagonally shaded. The posterior part of the axis is poorly preserved and does not show the scars ×2⅔.

They are faintly impressed on the outer surface of the exoskeleton, but more strongly on the inner surface, as the internal moulds show.

Through the kindness of Professor L. Størmer, I have examined material of *Ampyx mammilatus* Sars and "*A.*" *costatus* Boeck (Størmer, 1940, pp. 130–132, text-fig. 3, pl. II, figs. 5–18). This latter species, and "*A.*" *nudus* (Murchison) (Whittard, 1940, pp. 161–162, pl. V, figs. 9, 10) have a different pygidium from the type and may represent a separate genus.

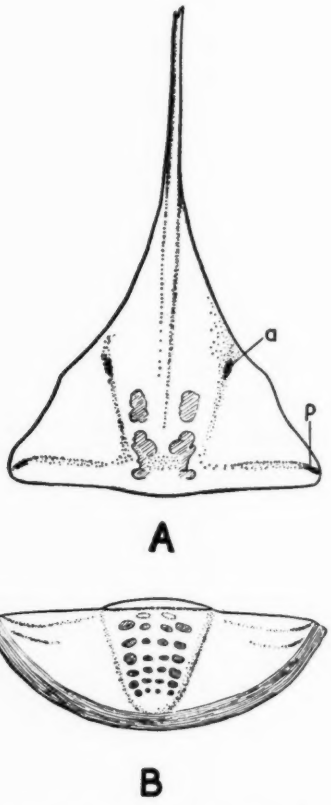


FIG. 7.—*Lonchodomas rostratus* (Sars). *7A*, dorsal view of the cranidium, drawn from PM 61749 (pl. *74*, fig. *11*). The muscle scars are diagonally shaded. a, anterior pit; p, pit at extremity of posterior marginal furrow. ×2¾. *7B*, dorsal view of pygidium, drawn from PM 56406 (262a) (pl. *74*, fig. *15*). The muscle scars are diagonally shaded. The anterior part of the axis is poorly preserved, and the probable position of the anterior pair of scars in the inner rows is shown by the dotted outline. ×4.

Genus LONCHODOMAS Angelin, 1854

Genotype.—By subsequent designation of Raymond, 1925, p. 30, *Ampyx rostratus* Sars, 1835.

LONCHODOMAS ROSTRATUS
(Sars), 1835
Plate 74, figures 11–15; text-figures 7A, B

Lectotype.—PM No. 56407, selected by Størmer, 1940, p. 130, from the *Ampyx* limestone, 4a β (high Lower Ordovician) of Huk, Bygdøy, Oslo region, Norway.

Geological range.—High Lower Ordovician to Upper Ordovician.

Description.—The cephalon is triangular in outline, the width slightly greater than the sagittal length (excluding the spines). The glabella is diamond-shaped in outline, convex and carinate, the anterior portion drawn out into a long prismatic spine, the length of the spine probably exceeds the length of the rest of the glabella; the occipital furrow is shallow and the occipital ring is flat and not marked off from the rest of the posterior border by the axial furrows. Three pairs of muscle scars occur (pl. 74, fig. 11; text-fig. 7A). The basal pair is situated in the occipital furrow, the second pair larger, subtriangular in outline, the third largest, ovate in outline, and situated about halfway between the point of maximum width of the glabella and the posterior border. As may be seen from the figures, a dark area, apparently also of muscle attachment, joins the basal and second scars. This area is sharply defined at the lateral margins, but is not divided medially. The cheeks are triangular in outline, and slope anterolaterally downwards from the shallow axial furrows. A deep elongate pit occurs at the anterior end of the axial furrow (*a* in text-fig. 7A). Eyes are absent. The facial suture is marginal anteriorly, crossing the ventral surface of the base of the spine and running along the margin of the anterior part of the cephalon, laterally cutting across the outer parts of the cheeks and the posterior border in a curve concave outwards. The free cheeks are small, subtriangular, drawn out into the prismatic genal spines, and anteriorly united by the flat ventral plate. The posterior marginal furrow is shallow, deepening outwards and

ending in a pit just inside the suture line (*p.* in text-fig. 7A); the posterior border is flat. The hypostome is unknown.

The thorax consists of five segments, the maximum width at the second segment. The axis is one-third the total width, gently convex, the axial furrows very shallow. The pleurae are horizontally extended, the outermost parts bent vertically down. The pleural furrows are narrow, deep, curving outwards and forwards and becoming deeper, especially on the last two segments.

The pygidium is wider than long, the posterolateral margins forming a smooth curve. The axis is gently convex, the axial furrows very shallow. Two pairs of suboval muscle scars occur on each segment (pl. 74, fig. 15, text-fig. 7B), the outer prominent, the inner fainter. The outer row appears to correspond with the appendifers in the articulating furrows. The side lobes are flattened, with a broad, steeply-sloping border, narrowest posteriorly. Two pairs of narrow pleural furrows are seen, curving outwards and forwards.

An ornament of fine, closely spaced punctae occurs on the cranidium, and terrace lines on the frontal spine and anterolateral slopes of the glabella, the genal spines, and the border of the pygidium.

Discussion.—The characteristics noted above are shown by the type material described by Størmer (1940, pp. 128–130, pl. 2, figs. 1–4) and additional topotype material, all of which I have examined. The specimens here figured show details not revealed by Størmer's illustrations. Plate 74, figure 12 shows the right free cheek and the base of the genal spine, as well as the punctate ornament. The ventral plate and the complete genal spines are not shown by the type material. The pattern of the muscle scars in both cephalon and pygidium of *Lonchodomas* is similar to that in *Ampyx*, except that the fourth glabellar pair are not seen in *Lonchodomas*. Both genera possess the deep anterior pits.

I have also examined specimens of *Lonchodomas macallumi* (Salter) and *L. drummuckensis* (Reed, 1903, 18–19, 21–22, pl. III, figs. 1–5, 11, 12), respectively from the Middle Ordovician Balclatchie beds and the Upper Ordovician Drummuck group, Girvan, Ayrshire, Scotland. They show all the characters discussed above, and the genal spines are long and gently curved. The same type of genal spines occur in *L. mcgeheei* (Decker, 1931; 1940) from the Simpson group of Oklahoma.

Genus AMPYXINA Ulrich, 1922

Genotype.—Gen? sp? Rowley, 1909, designated and named *Ampyxina bassleri* by Ulrich, 1922, p. 206. Probably *Endymionia bellatula* Savage, 1917, is synonymous with *A. bassleri*, and if so the earlier specific name of Savage's would have priority.

AMPYXINA BELLATULA (Savage, 1917)
Plate 73, figures 7, 8

Holotype.—The Rowley Collection was purchased by the University of Illinois in 1946. The specimens were not numbered, and the types have not yet been located.

Discussion.—Raymond (1925, pp. 47–49) has discussed *Ampyxina* and reviewed the evidence for believing that Savage and Rowley were dealing with the same species. If this argument be accepted, the specimens illustrated here are topotypes of *A. bellatula*. The characters of the thorax and pygidium are clearly revealed, and additional features of the cephalon shown. The "long, narrow basal lobes" of the glabella referred to by Raymond merge posterolaterally into the occipital ring and posterior border, and thus resemble the alae seen in *Raphiophorus* and *Raymondella*. In plate 73, figure 7 the suture line is seen on the left cheek lobe, and the internal mould of the narrow, rolled doublure of the free cheek appears as a groove at the margin. Plate 73, figure 8 shows the raised border on the free cheek, which is continuous with the genal spine.

Raymond placed *Ampyxina* in his family Endymionidae, but believed that it shared some characters with *Dionide* and *Raphiophorus*. The forward expanding glabella, alae, course of the facial sutures, and narrow curled doublure are raphiophorid characters, and I therefore consider that *Ampyxina* should be placed in this family, and not in the Endymionidae or Dionididae. The pygidium is more than twice as wide as long and distinctive among raphiophorids. The absence of a frontal glabellar spine is a character shared with *Raymondella*.

Genus RAYMONDELLA Reed, 1935

Synonym.—*Reedaspis* Prantl and Přibyl, 1948, accepting the arguments recently put forward by Sinclair (1949B).

Genotype.—By monotypy, *Ampyx* (?) *macconochiei* Nicholson and Etheridge, 1879.

RAYMONDELLA MACCONOCHIEI (Nicholson and Etheridge 1879)

Plate 74, figure 10; plate 75, figures 1, 2

Holotype.—BM In 20679, counterpart moulds, the original of Nicholson and Etheridge 1879, plate XIV, figure 1; 1880, Plate XIX, figure 9, from the lower Middle Ordovician Balclatchie beds, Balclatchie, near Girvan, Ayrshire, Scotland.

Other material.—From the type locality, BM In 20680 (mentioned in Reed, 1914, p. 5, and see this paper, pl. 75, fig. 2), BM In 369262–65 inclusive, the basis of Reed, 1935, plate III, figure 25.

Geological range.—Lower Middle Ordovician.

Description.—The entire trilobite is of maximum width (excluding the genal spines) about 6 mm. at the posterior margin of the cephalon, and the length is about the same; the length (sag.) of the cephalon is about two-fifths the total length.

The cephalon is subsemicircular in outline. The glabella is flask-shaped, the anterior part hemispherical in form, with a short, narrow convex neck (standing much lower than the anterior part), and a short convex occipital ring more strongly raised than the neck. A pair of deep oval pits runs inwards and forwards at the junction of the neck and the anterior part, and represents the basal glabellar furrows. The axial furrows are broad and deep. The cheeks are subtriangular in outline, strongly convex, raised higher than the occipital ring but less than the anterior glabellar lobe, sloping gently down to the axial and posterior marginal furrows, and steeply to the anterolateral borders. Eyes are absent, and the course of the facial sutures in *Raymondella*, if present, is not revealed by the available material. From the axial furrows at a point just behind the maximum width of the anterior glabellar lobe a broad shallow furrow runs directly back to the posterior marginal furrow, forming an inner boundary to the cheeks. Between this furrow and the axial furrow is a subcircular convex area, raised less than the glabellar neck, and apparently not separated from the posterior border. This area may represent the ala. The posterior marginal furrow becomes deeper laterally. The posterior border is convex. Only in the specimen In 36965 (pl. 75, fig. 1) is what appears to be a rolled border to the cephalon seen. This border has been interpreted by Reed (1935, p. 8 and pl. III, fig. 25) as developed on the dorsal side, and presumably separated from the cheek lobes and glabella by a furrow. Better preserved material is needed, however, to establish that this is really the case. In 36965 shows that the exoskeleton is curled under at the border to form the doublure, and a similar structure is seen in *Ampyxina* (pl. 73, fig. 7) and other raphiophorids. At the genal angles the border is prolonged into the genal spines, which are circular in cross section, gently curved and backwardly directed, and reach beyond the pygidium. The ornament on the glabella, alae, the furrow between the alae and cheek lobes, and the inner corner of the cheek lobes, is of small closely spaced tubercles. On the cheek lobes raised anastomosing ridges run subparallel to the anterolateral margins. A single line of tubercles occurs on the crest of these ridges, the intervening furrows being smooth.

The hypostome is unknown.

The thorax is of five segments, the first longest (sag.) and almost twice the length (sag.) of the last, with a progressive reduction in length backwards. The width of the axis is one-fifth the total width. The axial rings are strongly convex, the articulating furrows deep, with the lateral extremities extended ventrally as thick, short appendifers. The articulating half-ring reaches forwards to the articulating furrow of the next segment. The pleurae are horizontally extended, the tips bent down and back, with square terminations. The broad shallow pleural furrows separate a short (exs.) convex anterior band and a longer (exs.) more convex posterior band. An ornament of small closely-spaced tubercles occurs on the pleurae.

The pygidium is subtriangular in outline, about three times as wide as long, with a broad posterolateral margin bent vertically down. The axis is strongly convex, narrows

slightly backwards, and reaches and merges into the narrow raised posterolateral border; six prominent axial rings. Four corresponding pairs of furrows are seen on the side lobes, separated by three pairs of narrow ribs which merge into the border. A fine closely-spaced tuberculate ornament is seen on the side lobes, especially in the furrows.

Discussion.—Only the few specimens noted above of this small trilobite are known, no further ones having been discovered in later parts of the Gray Collection presented to the British Museum (Natural History) since the completion of Reed's monograph. Nicholson and Etheridge (1879, pp. 183–184, pl. XIV, fig. 1; 1880, p. 288, pl. XIX, fig. 9) first described this species, placing it in *Ampyx?* and later *Trinucleus.* Reed (1903, pp. 11–12; 1914, p. 5; 1935, pp. 8–9, pl. III, fig. 25) amplified the descriptions, placing the species in *Trinucleus?*, *Ampyx*, and finally *Raymondella*, a new subgenus of *Dionide.* I agree with Raymond (1925, p. 30) and Kobayashi (1940, p. 204) that *Raymondella* should be regarded as a genus within the family Raphiophoridae. It is evident from the figures and descriptions given above that *Raymondella* is similar to *Ampyxina* and *Raphiophorus*, and shares with these genera the following characters: the glabella expands forwards, alae are present, there are five segments in the thorax, and the pygidium is transverse. Both *Ampyxina* and *Raymondella* lack the frontal glabellar spine and possess the rolled cephalic border. The specimens of these three genera are comparable in size, and it seems likely that although small they are mature. *Raymondella* is distinguished by the hemispherical anterior glabellar lobe, and the ornament, particularly of the cheek lobes. It should be emphasized that the latter is tuberculate, and not punctate as stated in earlier descriptions. Tuberculate ornament is not known in other raphiophorids, and is not seen in dionidids.

Reed states in his description (1935, p. 8) that the glabella projects "in front above the border," but I am not sure that this is correct, in view of the imperfections of the material. The glabella may equally well descend vertically to the margin. Reed also states that the pleurae are crossed by a "ridge of nearly equal width," flanked by the narrow raised borders. It seems clear that "ridge" was printed in error for "furrow."

Family PHILLIPSINELLIDAE, new family
Genus PHILLIPSINELLA Novák, 1885

Genotype.—By original designation, *Phacops parabola* Barrande, 1846.

PHILLIPSINELLA PARABOLA (Barrande, 1846)
Plate 75, figures 3–7; text-figure 8

Discussion.—*Phillipsinella parabola* was first described from the Upper Ordovician (Ashgillian) Králův Dvůr shales of Bohemia (Barrande, 1852, pp. 477–478, pl. 18, figs. 24–29; 1872, p. 18, pl. I fig. 16), and is also characteristic of the middle Ashgillian of Britain (Reed 1904, pp. 85–86, pl. XII, figs. 1–2; 1931, pp. 11–12). Novák (1885) described the "hypostome" of *Phillipsinella* as a subrectangular body, without furrows, lobes or wings. He did not discuss the ventral sutures or how this unusual "hypostome" was attached. Begg (1943, p. 60, pl. II, fig. 8) described the hypostome of a Scottish specimen, and believed that Novák had "wrongly interpreted the impression of a broken-off part of the anterior glabellar lobe . . . as a hypostome." He further pointed out that the hypostome in his specimen is situated posterior to the anterior part of the glabella, but did not discuss the attachment of the hypostome or the course of the ventral sutures.

I have investigated specimens of *Phillipsinella parabola* from the upper Drummuck Group, Girvan, Scotland (BM In 21980, 41409, 40963, 40965, etc.) and Begg's original specimen (HM A. 735, 735a). They are preserved as counterpart moulds and rubber casts have been made from them. The dorsal exoskeleton is shown in plate 75, figure 7, and the anterior branch of the facial sutures runs forwards and outwards from the eyes at an angle of about 50° to the axis, and curves across the borders to run along the anterior margin as the rostral suture. The ventral exoskeleton of the cephalon appears to be as shown in text-figure 8, and both the rostrum (*r*) and the hypostome (*h*) are present. The doublure (pl. 75, figs. 3, 4) is narrow (tr.) laterally, becoming broader (sag.) as the axis is approached, so that the outline

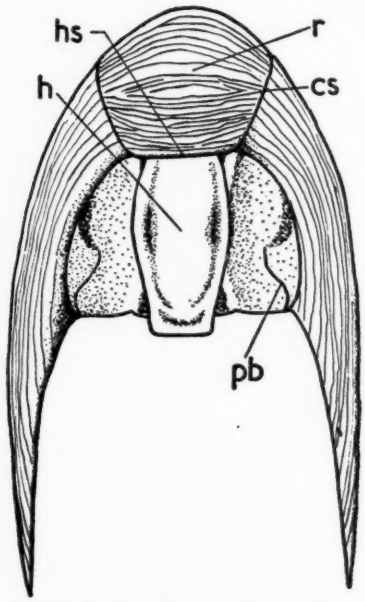


FIG. *8.—Phillipsinella parabola* (Barrande). Ventral view of the exoskeleton of the cephalon reconstructed from BM In 41409 (pl. *75*, fig. *4*) and HM A.735a (pl. *75*, fig. *5*). r, rostrum; cs, connective suture; hs, hypostomal suture; h, hypostome; pb, posterior branch of the facial suture. ×6.

of the inner margin is a semicircular curve reaching forwards to half the length of the cephalon. The outer part of the doublure is flattened, the inner border bent up dorsally. The rostral suture runs along the anterior margin of the doublure, the connective sutures run inwards at about 30° to the axis and along the line of the dorsal axial furrows. The rostral and connective sutures thus isolate the anterior portion of the cephalic doublure, and this plate, the rostrum, slightly displaced, is well seen in plate 75, figures 3, 4. Comparison of the casts from the counterpart moulds (pl. 75, figs. 4, 7) shows that this is a true ventral plate, and not merely an appearance due to crushing of the dorsal exoskeleton. The posterior margin is straight and bent dorsally, the rest of the plate having probably been flat, though crushed inwards in these specimens. BM In 40963 (pl. 75, fig. 3) suggests that there may have been shallow furrows running directly forwards from the posterolateral corners, and dying out as the anterior margin is approached. The doublure and genal spines are ornamented with terrace lines parallel to the margins. The rostrum was described as the "hypostome" by Novák (1885, pp. 3–5, pl. I, figs. 2, 3) and it seems clear that Novák's specimens only revealed a part of the plate and not the true boundaries. Further, this plate is homologous with the rostrum of other trilobites (e.g., Stubblefield, 1936, p. 411, fig. 2) and not the hypostome, which is a plate posterior to the doublure and separated from it by the hypostomal suture.

Only in the unique specimen described by Begg is the true hypostome preserved

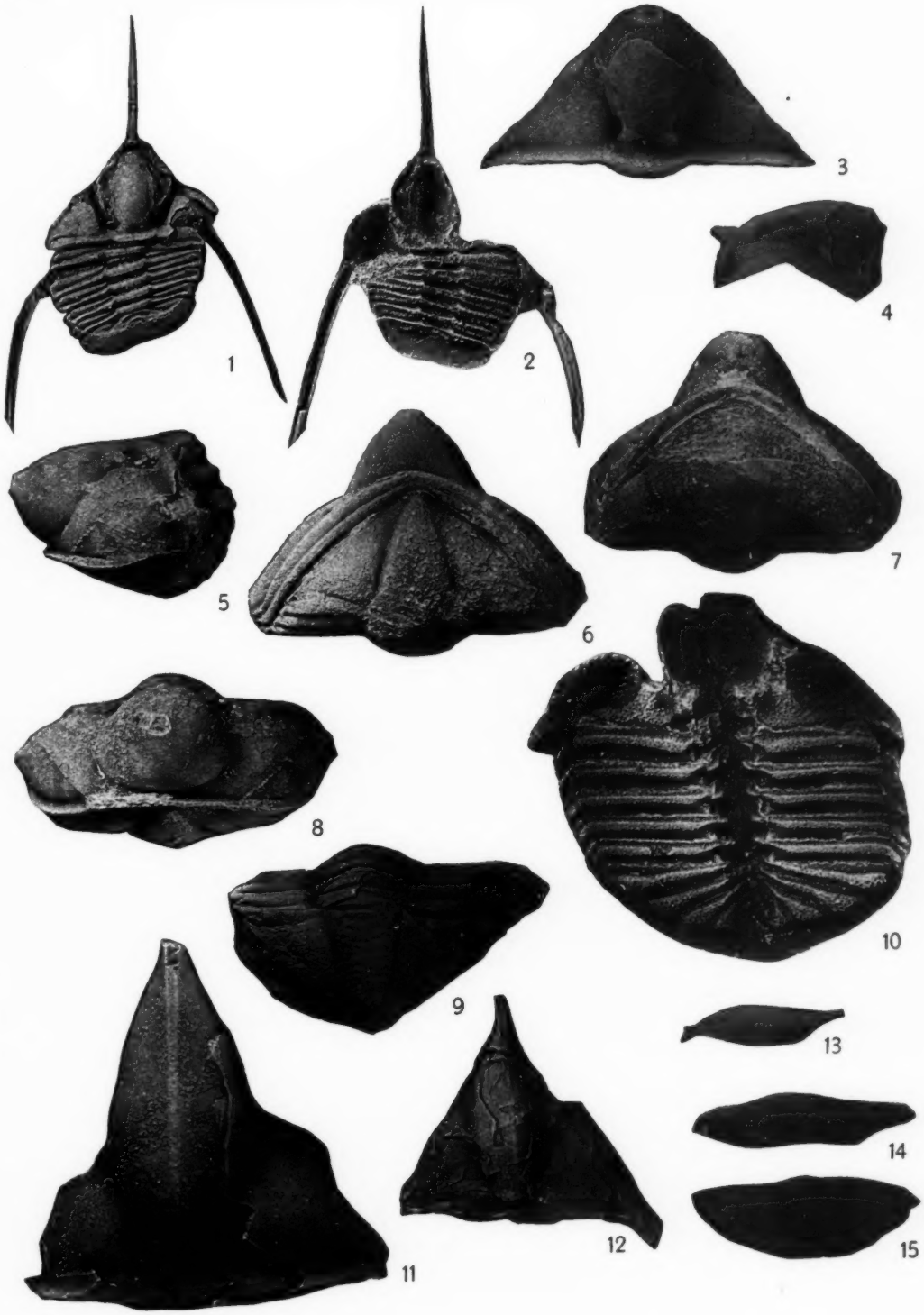
EXPLANATION OF PLATE 74

FIGS. *1–2—Raphiophorus setirostris* Angelin. The holotype and external mould, original of Angelin, 1854, pl. XL, fig. 6, ×5. *Tretaspis* shale, Draggå bro, Dalarna, Sweden, RS Ar. 9248. (p. 553)

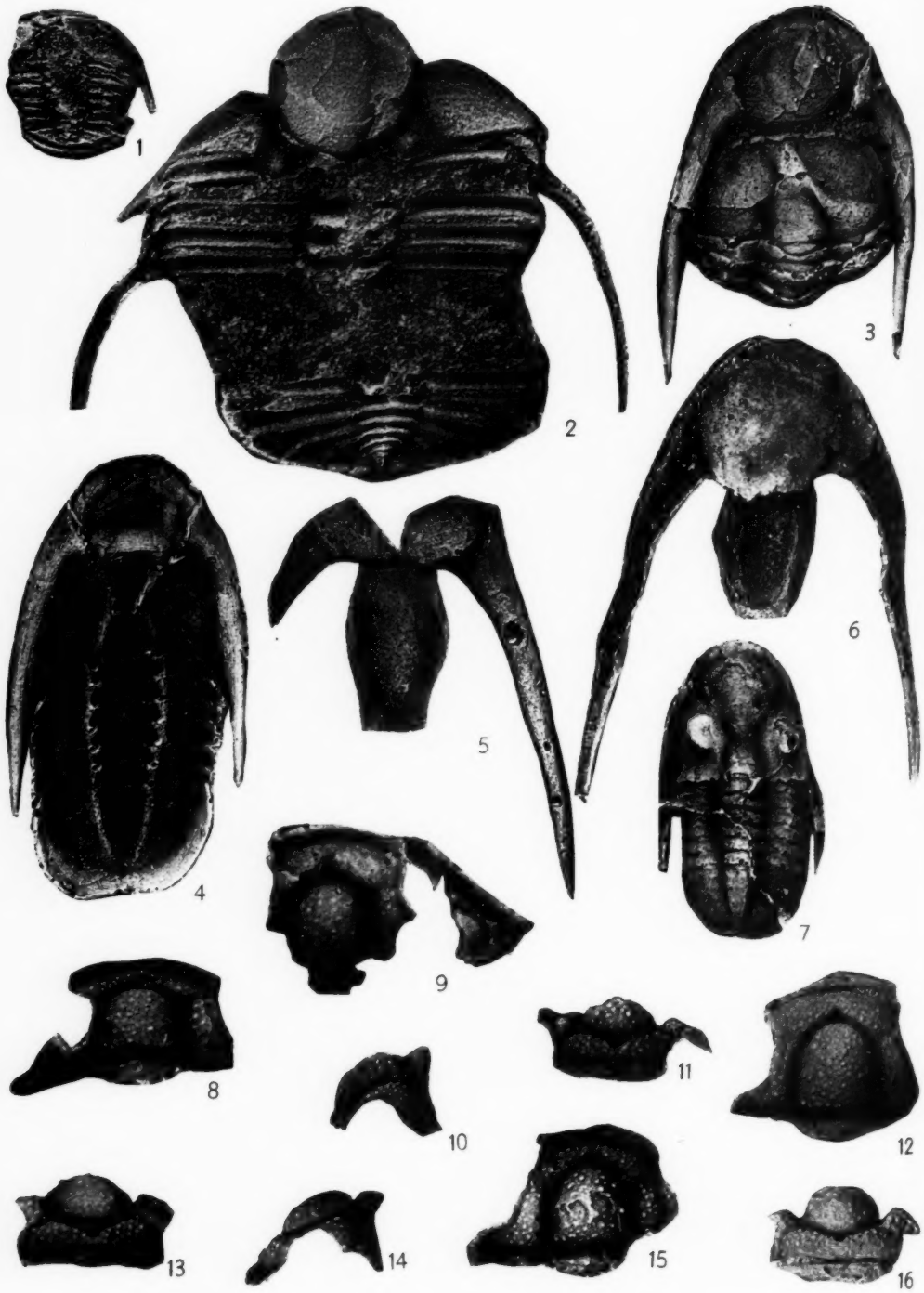
3–9—Ampyx nasutus Dalman. *3*, *4*, dorsal and lateral views of a cranidium showing muscle-scars (cf. text-fig. *6A*), ×2. *Asaphus* limestone, Öland, Sweden, RS Ar. 13400. *5*, *6*, *8*, lateral, ventral and anterior views of the neotype, an enrolled specimen, ×2. *Asaphus* limestone, Västanå, Östergötland, Sweden, RS Ar. 13394. *7*, ventral view of a partially enrolled specimen, showing the cephalic doublure and the border of the pygidium, ×2. Horizon and locality as fig. *5*, RS Ar. 13399. *9*, pygidium of an enrolled specimen showing muscle-scars on the axis (cf. text-fig. *6B*), ×2. Horizon and locality as fig. *5*, RS Ar. 13398. (p. 554)

10—Raymondella macconochiei (Nicholson and Etheridge). The holotype, an external mould, showing the ornament, ×8. Balclatchie Beds, Balclatchie, Girvan, Ayrshire, Scotland, BM In 20679. (p. 558)

11–15—Lonchodomas rostratus (Sars). *11*, cranidium, the internal mould of the glabella showing muscle-scars (cf. text-fig. *8A*), ×4. *Ampyx* limestone, Huk, Bygdøy, Oslo region, Norway, PM 61749. *12*, incomplete cephalon showing base of right genal spine, ×2. Horizon and locality as fig. *11*, PM 56410g. *13*, lateral view of cranidium, ×2. Horizon and locality as fig. *11*, PM 56410d. *14*, posterior view of pygidium to show border, ×3. Horizon and locality as fig. *11*, PM 56406. *15*, internal mould of pygidium, showing muscle-scars (cf. text-fig. *7B*), ×3. Horizon and locality as fig. *11*, PM 56406 (262a). (p. 556)



Whittington, *Raphiophorus, Ampyx, Raymondella, Lonchodomas*



Whittington, *Raymondella, Phillipsinella, Törnquistia*

(pl. 75, figs. 5, 6). The internal mould shows that the straight anterior margin lies against the bent-up posterior margin of the rostrum. The hypostome extends back beneath the narrow posterior half of the glabella to, or slightly beyond, the posterior margin. The middle body is oval in outline, convex, the lateral and posterior furrows deep, the borders narrow. The lateral furrows become deepest and broadest at about half the length. Apparently faint, shallow furrows run inwards and backwards on to the posterolateral parts of the middle body.

An enrolled specimen of *Phillipsinella parabola* is shown in plate 75, figure 3. A comparison with the extended specimen in plate 75, figure 4 reveals the outline which enables the close fit of the pygidium against the inner margin of the cephalic doublure. This type of enrollment contrasts with that in such trilobites as asaphids or illaenids, in which the posterior margin of the pygidium fits against the anterior margin of the cephalon, and not against the inner margin of the doublure. The type of enrollment seen in *Phillipsinella* is perhaps made necessary by the relative shortness of the thorax and length of the hypostome.

Novák (1885, p. 5) and Reed (1931, pp. 11–12) suggested that *Phillipsinella* belonged with the Asaphidae or Styginidae, Reed favoring the latter family. The large rostrum and the long, narrow hypostome are quite different from those of styginids, and asaphids have a median suture. These characters, added to the distinctive features of the dorsal exoskeleton, preclude reference of *Phillipsinella* to either of the two families mentioned. I consider that it should be placed in a separate family, for which the name Phillipsinellidae is proposed.

Family uncertain

Genus TÖRNQUISTIA Reed, 1896

Genotype.—By subsequent designation of Warburg (1925, p. 198), *Cyphaspis* (*Törnquistia*) *nicholsoni* Reed, 1896.

TÖRNQUISTIA NICHOLSONI Reed, 1896.
Plate 75, figures 8–16; text-figure 9

Lectotype (here selected).—Sm A.11913, the original of Reed, 1896, pl. XXI, fig. 3, from the Upper Ordovician (middle Ashgillian *Phillipsinella parabola* zone) Keisley limestone of Keisley, Westmorland, England.

Other material.—From the type locality SM A.11914, the original of Reed, 1896, pl. XXI, figure 3a, SM A.11915–16 inclusive.

Geological range.—Middle Ordovician to Lower Silurian. The species described from Balclatchie (see below) is placed in this genus, and Warburg (1925, pp. 195–205, pl. V, figs. 40–48) has described species from the lower and upper *Leptaena* limestone of Sweden. The latter is now regarded as being of Lower Silurian age (see Warburg, 1939, pp. 3–4).

EXPLANATION OF PLATE 75

FIGS. *1–2*—*Raymondella macconochiei* (Nicholson and Etheridge). *1*, internal mould, showing part of border of cephalon, thorax, and pygidium, ×4. Balclatchie beds, Balclatchie, near Girvan, Ayrshire, Scotland, BM In 36965. *2*, internal mould, the posterior margin of the cephalon incomplete and the thorax disarticulated, ×10. Horizon and locality as fig. *1*, BM In 20680. (p. 558)

3–7—*Phillipsinella parabola* (Barrande). *3*, rubber cast from internal mould of enrolled individual, showing the rostrum, ×4½. Starfish bed, upper Drummuck Group, Thraive Glen, near Girvan, Ayrshire, Scotland, BM In 40963. *4*, *7*, rubber casts of counterpart moulds, ×4½, ×3. Horizon and locality as fig. *3*, BM In 41409. *5*, *6*, rubber casts of counterpart moulds, showing the anterior and lateral part of the cephalon, including the hypostome. The external mould is the original of Begg, 1943, pl. II, fig. 8, ×4½. Horizon and locality as fig. *3*, HMA 735. (p. 559)

8–16—*Törnquistia nicholsoni* Reed. *8*, *13*, *14*, dorsal, anterior and lateral views of the lectotype, the original of Reed, 1896, Pl. XXI, fig. 3, ×9. Keisley limestone, Keisley, Westmorland, N. England, SM A.11913. *9*, dorsal view of an incomplete cranidium, on the right of which is the fragment figured as the free cheek by Reed, 1896. Pl. XXI, fig. 3a, ×9. Horizon and locality as fig. *8*, SM A.11914. *10*, *11*, *15*, lateral, anterior and dorsal views of an incomplete cranidium, ×9. Horizon and locality as fig. *8*, SM A.11916. *12*, *16*, dorsal and anterior views of an incomplete cranidium, ×9. Horizon and locality as fig. *8*, SM A.11915. (p. 561)

Description.—The cephalon is semicircular in outline, strongly convex, the maximum height about one-third the width. The glabella reaches forwards to two-thirds the length (sag.) of the cephalon, the maximum width at the base almost one-third the width of the cephalon; tapering slightly forwards, rounded anteriorly, convex, outlined by deep continuous axial and preglabellar furrows, the maximum height at the midpoint; without glabellar furrows, the occipital furrow broad, straight, with an almost vertical anterior slope, a gentle posterior slope, and becoming deeper and narrower at the extremities; the occipital ring convex, longest sagittally, the posterior margin arcuate; the ornament of closely and irregularly spaced coarse tubercles, with a larger median tubercle on the occipital ring. The preglabellar field is convex, sloping steeply downwards and forwards as well as into the preglabellar furrow, bounded laterally by shallow furrows, which, commencing in the axial furrows opposite the anterolateral corners of the glabella, run forwards and outwards, then, becoming very faint, turn to run directly forwards just inside the anterior branch of the facial suture; a deep pit, elongated longitudinally, occurs in the midline of the preglabellar furrow and extends into the preglabellar field. The anterior border is convex, the anterior furrow broad (sag.) and deep. The preglabellar field with similar ornament to the glabella. The fixed cheeks are L-shaped in outline, convex, inside the eye sloping steeply down to the axial furrows, the inner posterior corners inflated, with a vertical slope down to the posterior marginal furrow; the posterior branch of the facial suture runs outwards and slightly backwards in a sigmoidal curve, turning to run directly backwards across the posterior border; the ornament of irregularly spaced tubercles. The posterior border is short (exs.) and convex at the inner end, becoming longer (exs.) and flat laterally, until the length (exs.) at the outer margin is equal to the maximum length (sag.) of the occipital ring. The posterior marginal furrow is deepest at the inner end, becoming shallower outwards.

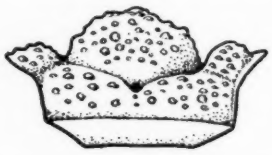


FIG. 9.—*Törnquistia nicholsoni* Reed. Anterior view of the cranidium drawn from SM A. 11916 (pl. 75, fig. 11). c. ×14.

Discussion.—The holotype cranidium is an internal mould, and the palpebral lobes are broken off, so that no further details can be discerned. Three other cranidia are known, and none of them has the palpebral lobes well preserved. It appears that the anterior margin of the eye is situated just behind the anterolateral furrows that bound the preglabellar field. The posterior margin is opposite a point about half the length of the glabella. Two specimens (pl. 75, figs. 11, 16; text-fig. 9) show the anterior border clearly. The anterior branches of the facial suture run directly forwards to cross the anterior furrow, and then turn to run inwards and forwards across the outwardly sloping anterior border, but not reaching the midline at the anterior margin, being separated by a distance equal to about half the width of the preglabellar field. It is presumed that the median part of this anterior margin is formed by the rostral suture, and that *Törnquistia* possessed a narrow rostrum similar to that of the Proetidae and Otarionidae (see e.g., Barrande, 1852, pl. 2B, figs. 16, 18).

Reed (1896, p. 434 and pl. XXI, fig. 3a; this paper, pl. 75, fig. 9) described a specimen that he believed might be the free cheek. It is near to an incomplete cranidium, and shows a convex area that may be the eye surface, close outside which is a broad, shallow, straight furrow. The outline appears to be triangular as Reed depicted it, and apart from the eye surface, the free cheek is flat. This last fact must mean that the specimen, if it is the free cheek, is distorted, for the free cheek belonging to the cranidium described above must be convex. I consider that this specimen is too poorly preserved to allow it to be identified with certainty.

Warburg (1925, pp. 200–202, pl. V, figs. 40–44) has described this species from the upper *Leptaena* limestone of Sweden. The

description corresponds closely to that given above, except that the Swedish form shows two pairs of glabellar furrows on the better-preserved specimens. The free cheek is known in the Swedish material, and other species occur.

Reed (1904, pp. 86–87, Pl. XII, figs. 3–7) described a species from the lower Middle Ordovician Balclatchie group of Girvan, which he first called *Menocephalus ? (Törnquistia)* cf. *nicholsoni*, but later *Hystricurus translatus* Reed 1931 (pp. 6–7). I have examined the type and other material (BM In 22641–47 inclusive), and can see no justification for placing this species in *Hystricurus* Raymond, 1913 (p. 60). The cranidium does not have the "deeply concave border in front," and the axial furrows are not "paralleled by a narrow convex ridge." The cranidium is similar to that of the genotype of *Törnquistia*, and I believe that "*H.*" *translatus* should be placed in this genus. *T. translatus* is of interest in that the thorax and pygidium are known (Reed, 1904, pl. XII, fig. 6), and this pygidium is quite unlike that of *Hystricurus*. The thorax and pygidium of *Törnquistia translatus* recall those of *Dimeropyge* Öpik (see Sinclair, 1946), and it is possible that these two genera are related. I intend to discuss this question further when describing silicified specimens of *Dimeropyge*.

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Museum of Comparative Zoology at Harvard College (Formerly University of Birmingham, England.)

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JOURNAL OF PALEONTOLOGY, VOL. 24, NO. 5, PP. 566–570, PL. 76, 1 TEXT FIG., SEPTEMBER 1950

THE STRUCTURE AND RELATIONS OF *CYCLOGRAPTUS* SPENCER

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ABSTRACT—The species *Cyclograptus rotadentatus* Spencer is redescribed on the basis of syntype material from the Spencer Collection in the Royal Ontario Museum of Palaeontology, and the relations of the genus *Cyclograptus* are discussed. It is confirmed that the genus is closely related to *Galeograptus* Wiman and should be placed with that genus and *Discograptus* Wiman in Kozlowski's Family Idiotubidae, (Order, Tuboidea).

THE name *Cyclograptus* was proposed by Spencer in 1882 and the genus described in 1883 and 1884 for a species of dendroid graptolite occurring in the Niagara limestone of Hamilton, Ontario. The original description gave little indication of the morphology of the genus, and is indeed inaccurate in two suppositions, and the accompanying figures were poor.

> In this genus, the frond consists of a circular disc which was probably cup-shaped in its growing form, though flattened in a concave manner in the rock. From the radicle many stipes radiate through the non-celluliferous disc to its margin and thence in a free manner to some distance beyond. The whole frond resembles a solid wheel, where the radiating spokes extend from the centre regularly to beyond the circumference. The branches beyond the disc are celluliferous. The stipes have a central solid axis. The substance is highly corneous, though in some places replaced by pyrites. (1884, p. 592)

Subsequently, Wiman (1901) gave a detailed description of two genera, *Discograptus* and *Galeograptus*, from chert nodules in the limestone boulders of Öjle Myr, Gotland; and Ruedemann (1908) recognized the general similarity of these (and the Bohemian *Rodonograptus* Počta) to Spencer's *Cyclograptus*. Ruedemann recorded and described another specimen of Spencer's species from the Clinton group, but was unable to add materially to our knowledge of the structure of *Cyclograptus*.

In 1938, the writer proposed the family Cyclograptidae for the genera above mentioned (including also possibly Spencer's *Calyptograptus*), basing the latter part of the family diagnosis on information received in litt. from Professor Kozlowski.—

> Rhabdosome consisting of a basal disc from which numerous stipes arise independently.
> The mode of development is incompletely known, but there are indications in some genera of a concentration of budding individuals in the basal region and there is a tendency for the bithecae, in those genera known to possess them, to be restricted to the basal portion of the rhabdosome. (1938, pp. 22, 23)

while Kozlowski himself in the same year transferred the genus *Cyclograptus* from the Dendroidea to his new order, Tuboidea.

All this time, no real details of *Cyclograptus* have ever been published and it seemed desirable to reexamine the specimens of that genus preserved in the Royal Ontario Museum of Palaeontology, Toronto. I am very greatly indebted to Dr. Madeleine A. Fritz for affording me facilities for the study of this material; and now that Kozlowski's exhaustive memoir (1949) has been published, we are in a position to appraise the morphology of the Tuboidea and are better able to interpret both the structure of *Cyclograptus* and its relations to *Galeograptus* and *Discograptus*.

ORDER TUBOIDEA Kozlowski

Rhabdosome sessile, erect or encrusting, composed of autothecae, bithecae and stolothecae; budding capricious, commonly diad but very variable.

Family IDIOTUBIDAE Kozlowski

Rhabdosome an encrusting assemblage of thecae (thecorhiza) from which arise tubular autothecae singly or in groups; stolothecae confined to thecorhiza; initial portion of autothecae horizontal, incorporated in the thecorhiza, distally tubular, erect; bithecae limited to thecorhiza or extending slightly beyond it associated with bases of autothecae or groups of autothecae.

There is a graded series from *Idiotubus* Kozlowski, with isolated autothecae, to *Galeograptus*, with thecae grouped into relatively complex branches which possibly (though in Kozlowski's view improbably) contain stolothecae. It is in this family that Kozlowski includes Spencer's *Cyclograptus*.

Kozlowski's "Informations préliminaires" was published almost simultaneously with my "Graptolithina" (*Handbuch der Paläozoologie*) in 1938, and although we had been in correspondence, we had proposed different names (Idiotubidae and Cyclograptidae, respectively) for virtually the same assemblage of genera. At this distance of time, I cannot recollect which had absolute priority, but I propose to regard my Cyclograptidae as a synonym of Idiotubidae, for the sufficient reason that it allows a diagnosis of the family in terms of detailed thecal structure. For this procedure involves recognition as type of a genus (*Idiotubus*) in which the detailed structure is known, though not the shape and appearance of the entire colony; rather than *Cyclograptus* in which general form is well-known, but the thecal structure and composition is even now only imperfectly understood. Even though *Cyclograptus* is thus no longer regarded as the type of a family, it status as the oldest described genus of the family merits description of its structure so far as can be determined, to justify its inclusion with *Discograptus* and *Galeograptus* in the Idiotubidae.

Genus CYCLOGRAPTUS Spencer

Cyclograptus SPENCER, 1882, p. 165 (nomen nudum).—SPENCER, 1883, p. 365.—SPENCER, 1884, p. 592.—RUEDEMANN, 1908, pp. 182–4.—BASSLER, 1909, pp. 44–5.—BASSLER, 1915, p. 330.—BULMAN, 1938, p. 23.—KOZLOWSKI, 1938, p. 187.—RUEDEMANN, 1947, pp. 139, 249.—KOZLOWSKI, 1949, pp. 108, 142–4.

Genotype (monotypy).—*Cyclograptus rotadentatus* Spencer 1884.

Diagnosis.—As for the species.

CYCLOGRAPTUS ROTADENTATUS Spencer

Cyclograptus rotadentatus SPENCER, 1882, p. 165 (nom. nud.).—SPENCER, 1884, pp. 592–3, pl. 6 figs. 6, 6a.—MILLER, 1889, p. 182, fig. 162.—GURLEY, 1896, pp. 94, 309.—RUEDEMANN, 1908, pp. 184–5, pl. 2, fig. 5, text-figs. 91, 92.—BASSLER, 1909, pp. 45–6, figs. 57, 58.—RUEDEMANN, 1947, pp. 249–250, pl. 35, figs. 5–7.

Lectotype.—Three specimens are preserved in the Royal Ontario Museum:—the largest (1718N), little more than a stained impression, bears the MS label "*Cyclograptus rotadentatus* (Spencer), Niagara Chert, Sil., Hamilton, Ont."; the second (1449N) is labelled "Spencer Collection" with the MS label "*Cyclograptus rotadentatus* (Spencer), Niagara, Hamilton, Ont."; and the third (21623), recorded in the published Catalogue (Fritz, 1941, p. 45) as *neotype*, bears no MS label, but belonged to the Spencer Collection. Spencer's original figure is schematic and his dimensions only approximate; it is not therefore safe to conclude that no.21623 is the holotype though it is the best and most complete specimen. It is very probable, however, that it was one of Spencer's

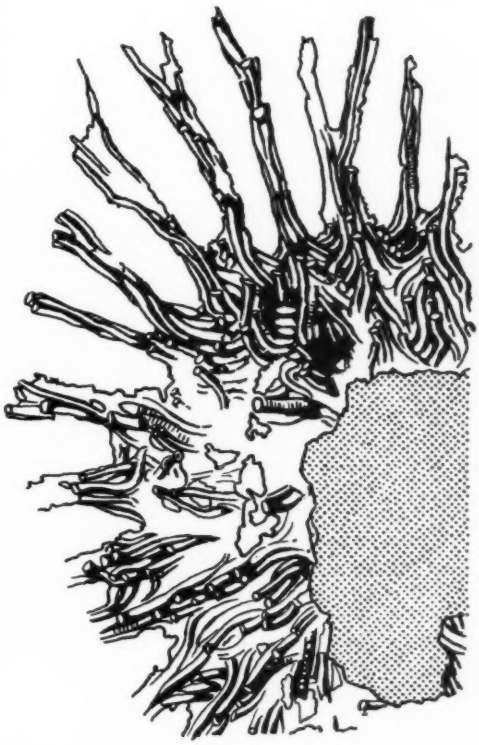


FIG. 1.—*Cyclograptus rotadentatus* Spencer. Portion of lectotype, 21623 Roy. Mus. Pal. Ont., ×7.5, showing thecal tubes in the thecorhiza and bases of stipes; stippled area, the superficial carbonaceous lamina.

syntypes (he refers to "two specimens and two casts"), and on that assumption it is here selected as lectotype.

Description

Lectotype (*21623*) (pl. 76, figs. 3a, 3b, text-fig. 1.)

Rhabdosome elliptical, 18 mm. ×13 mm., composed of 28 short stipes radiating from a central disc (thecorhiza) measuring approximately 11 mm.×9 mm.

The greater part of the periphery of the thecorhiza is seen to be composed of an interlacing mass of fine (pyritized) approximately radiating, tubular thecae; the central part, extending to the periphery over one segment, is covered with a black, carbonaceous lamina. The latter is strongly concave, marked with faintly defined radiating rugae which are related to the peripheral branches, and which evidently gave rise to Spencer's view that the rhabdosome consisted of radiating stipes originating at the center and bound together by a membrane. There are also faint suggestions of roughly concentric growth lines in one small area.

Clearly, this lamina once covered the entire surface of the central disc, and since there appear to be no thecal openings anywhere on its surface, it may represent the lower side (attached side) of the thecorhiza. On the other hand, in the decorticated portion of the thecorhiza, the thecal tubes seem mainly to rise distally (so that the broken end is usually the distal end) and this suggests that it is the *upper* surface. If this be correct, then thecal openings were apparently confined to the stipes and bases of the stipes.

Free stipes average 4–4½ mm. in length where fully preserved and some half-millimeter in breadth. Some seem just to have bifurcated before becoming free at the margin of the disc; rather less than half bifurcate in their free portion, usually at about their midlength, and these appear to be stouter. The inference is that the stipes are not composed of a uniform number of thecae; and that those possessing a larger number divide while smaller aggregates do not. Thecal tubes to compose a branch are drawn together from a fairly wide area of thecorhiza, suggesting that budding is confined to the thecorhiza and there are no stolothecae in the branches themselves. Twelve to sixteen thecae, perhaps more, are present in each stipe (or at least at its base). There is some indication that thecal tubes open in small groups or "twigs," but these do not seem to be in any way definite nor (if budding is confined to the thecorhiza) would they be expected to be. On the whole, branching and the composition of the branches appears to be irregular.

Thecal tubes average rather more than one-tenth millimeter (about 0.12 mm.) in diameter. There is no very marked difference between autothecae and bithecae, assuming both to be present, but bithecae are presumably the more slender; and there is no sign of any apertural modification, though the distal portion of the stipes is poorly preserved and mostly broken. Kozlowski's observation (relating to *Dendrotubus* and *Discograptus*) that the distal thecae are younger and to some extent moulded against the more central (older) thecae applies equally to *Cyclograptus*. Traces of growth lines are present on some thecae, but the preservation is not good enough to admit any accurate observations.

Specimen 1449N (pl. 76, fig. 2).

The rhabdosome seems to have been more

Explanation of Plate 76

Cyclograptus rotadentatus Spencer, Niagara limestone, Hamilton, Ontario; Spencer Collection.
All specimens in Royal Ontario Museum of Palaeontology, Toronto. Photographs retouched.

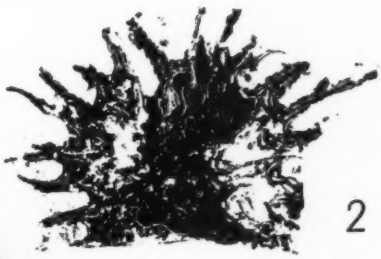
FIG. *1*—Specimen 1718N. Brown-stained external cast of presumed lower surface from which most of the graptolitic substance has been weathered away. ×3. (p. 569)

2—Specimen 1449N. Small, nearly circular rhabdosome, extensively weathered on left and right sides; central area covered by a carbonaceous lamina. ×3. (p. 569)

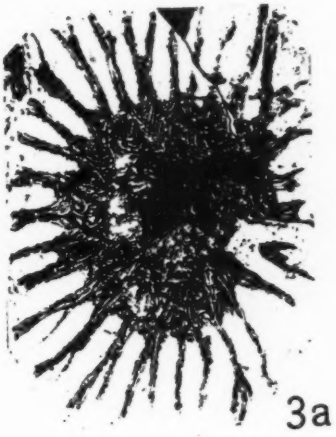
3a—Lectotype, specimen 21623. Most complete and best-preserved example. Lower right hand sector preserves the carbonaceous lamina, the remainder decorticated, showing radial, interlacing thecal tubes extending into the branches. ×3. (p. 568)

3b—Portion of same, ×7.5. (p. 568)

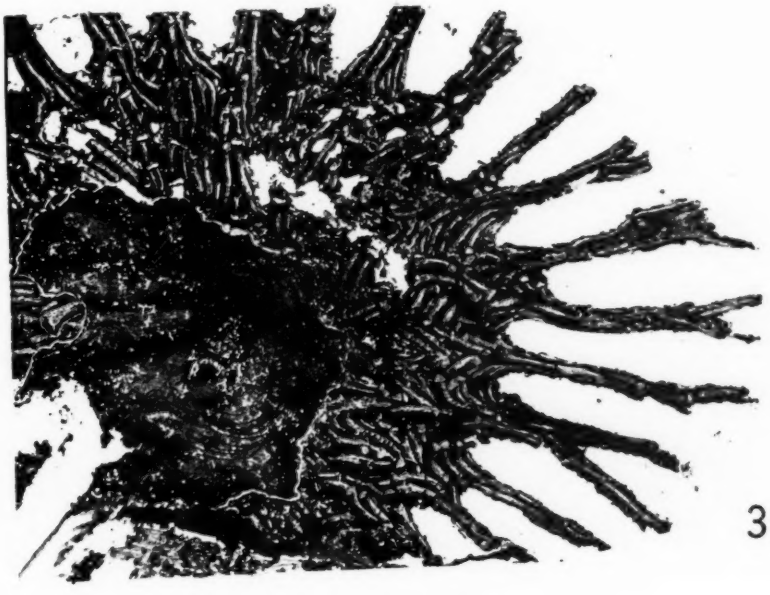
1



2



3a



3b

Bulman, *Cyclograptus*

nearly circular, 16 mm. in diameter, with central disc (thecorhiza) 10 mm. diameter; 16 stipes are preserved, but very nearly half have been broken away.

The specimen is broken and is more seriously abraded than the lectotype, but shows similar remains of a superficial lamina extending across the center, with radial rugae (not so well marked) corresponding to the branches, and traces of thecal tubes visible through its substance.

The stipes, composed of fascicles of tubes drawn from the thecorhiza, are rather more conspicuously paired than in the lectotype (as though they had already divided) and only four divide again. They are rather more unequal as to number of thecal tubes of which they are composed.

Specimen 1718N (pl. 76, fig. 1).

Rhabdosome somewhat distorted so that impressions of stipes are seen on three sides only and the stipes are not truly radial; dimensions 25 mm.×20 mm., thecorhiza 18 mm.×14 mm.: traces of about 30 branches, with an additional six to eight not visible.

The specimen consists of an impression or cast, stained brownish, with some fragments of carbonized chitin around the tips of some of the branches and in the central part of the thecorhiza.

The thecorhiza shows sinuous radiating impressions of thecal tubes, seemingly radiating from a curious eccentric scar 5×3 mm. with irregular outlines, bordered by carbonized chitin and perhaps representing a disc of attachment. If this is so, it indicates that the rhabdosome was attached by a relatively small central portion of the thecorhiza, the peripheral portions being raised above the object on which it was growing; and the other two specimens (21623 and 1449N) were both noticeably concave on what was considered to be the upper surface (i.e., saucer-shaped). Spencer's inference that the rhabdosome was "cup-shaped in its growing form" would therefore be justified. Specimen 1718N is presumably presenting a cast of the lower surface of the rhabdosome, so that possibly the majority of the thecal tubes represent stolothecae; and certainly there appear to be traces of bifurcation.

Despite the larger size of the rhabdosome, the stipes remain of comparable length (4½–5 mm.) and only some four or five of those visible divide again at about their midlength; their estimated number (36–38) is appreciably greater than in the two smaller rhabdosomes.

EMENDED SPECIFIC DIAGNOSIS

Rhabdosome 2–2½ cm. diameter, consisting of some 30–35 stipes radiating from a central disc or thecorhiza 1–1½ cm. diameter, composed of a mass of fine, approximately radial, tubular thecae. Upper surface of thecorhiza covered with a layer of cortical tissue devoid of thecal openings, which seem to be confined to the stipes and bases of the stipes; lower surface attached centrally, probably free peripherally. Stipes 4–5 mm. in length, composed of the distal portions of some 12-16 thecae drawn together from the thecorhiza, the larger stipes bifurcating once near their midlength. Thecal tubes 0.12–0.15 mm. in diameter; bithecae not clearly distinguishable, probably the slightly narrower more laterally-placed thecae of the stipes; stolothecae apparently confiend to the thecorhiza.

RELATIONS AND AFFINITIES

Ruedemann (1907, p. 183) was clearly correct in recognizing the general affinity existing between *Cyclograptus*, *Discograptus* and *Galeograptus*, and the rhabdosome in all three genera is constructed on the same general plan. All three are also, at present, monotypic, but the differences are probably of generic value.

As Kozlowski has shown in his recent analysis of the genus (1949, pp. 142–144), *Discograptus* consists of a circular thecorhiza with groups of thecae arising all over its surface. Near the center are several autothecae (one of which is no doubt the sicula) whose apertures are on a level with the surface of the thecorhiza so that only the apertural processes arise above it. Along numerous radii, other groups of thecae arise, the length of the branches and the number of thecae of which they are composed increasing steadily from the center to the periphery: and peripherally there are about twenty branches. Assuming we are correct in our identification of the upper

surface of *Cyclograptus*, there is clearly an important distinction here; for in *Cyclograptus* the branches are confined to the periphery and the upper surface of the thecorhiza appears devoid of thecal openings.

Galeograptus is closer to *Cyclograptus* in that the branches are confined to the periphery, but they are there proportionately longer, fewer in number, and composed of far more numerous thecae; there are nine or ten branches, composed (at their bases) of some 40–50 thecae, having a length of seven millimeters, and all bifurcating once and sometimes twice in that length.

Cyclograptus, then, though closely comparable with *Galeograptus*, is distinguished by the greater number of its branches, their smaller size (both number of thecae and length) and less tendency to bifurcation. So far as can be determined, it is also distinguished from both *Discograptus* and *Galeograptus* by the absence of any apertural spines to the thecae; but preservation does not admit of any definite pronouncement on this point.

In Počta's *Rodonograptus* and Spencer's *Calyptograptus*, the thecorhiza, if present at all, is far less prominent than in any of the above-mentioned genera. Počta (1894) was uncertain whether the appearance of a basal disc in *Rodonograptus* was not simply due to compression of the closely-approximated stipes near their common origin; and in *Calyptograptus* there is no discoidal structure but only a short, very thick, stalk. Possibly both these genera will eventually be found to belong to Kozlowski's Tubidendridae, in which there is no thecorhiza, but stolothecae somewhat irregularly developed occur along the ramifying stipes.

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NEW SPECIES OF *UTHAROCRINUS* AND *LASANOCRINUS*

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ABSTRACT—Several forms from the Missourian and Virgilian of Oklahoma and Kansas are described as *Utharocrinus habitus*, n. sp., *U. spinosus*, n. sp., *U. fabulosus*, n. sp. and *U. facilis*, n. sp. One form from the Desmoinesian is described as *Lasanocrinus altamontensis*, n. sp.

INTRODUCTION

THE genus *Utharocrinus* Moore and Plummer was proposed with *Delocrinus pentanodus* Mather as the genotype species. To quote Moore (1939), "The chief distinguishing feature of *Utharocrinus* is the more or less strongly developed spines or nodes on the BB." Moore (1939) indicated hesitation in assigning three species (*U. topekensis* Moore, *U. oreadensis* Moore and *U. quinquacutus* Moore) from the Virgilian to the genus. However, from available information, there apparently was no choice in the matter. In both *U. oreadensis* and *U. topekensis* there is evidence of nodular protuberances on the RR as well as on the BB, particularly in the later species. In "Index Fossils of North America, 1944," Moore and Laudon list both *U. pentanodus* and *U. quinquacutus* under the genus.

Bramlette (1943), described a form as *Triceracrinus moorei*, new genus, new species. This form is congeneric with *Utharocrinus* as accepted at present. Bramlette placed considerable importance on the triangular shape of the PBrBr; however, this general type of primibrach was reported by Strimple (1939), for *U. granulosus* Strimple.

The author desires to express his dissatisfaction with the existing status of *Utharocrinus*. It is most unlikely that the younger forms are of the same genus as *U. pentanodus*, the genotype species. The species *U. facilis*, which is described below, indicates closer affinity with *Perimestocrinus* than with *Utharocrinus*, particularly when compared to *P. noduliferous* (Miller and Gurley), the genotype species of that genus. Rather than further confuse matters by proposing more changes on inadequate knowledge it seems advisable to endeavor to establish firmly the existing genera.

It might be noted that at the time the species *U. granulosus* Strimple was presented the author inadvertently failed to designate the holotype which is that specimen figured on plate 2, figure 2. The two other partial crowns are to be considered as paratypes and the dorsal cup figured on plate 2, figures 5–6 may belong to an undescribed species.

Four forms are described as *Utharocrinus habitus*, n. sp., *U. spinosus*, n. sp., and *U. fabulosus*, n. sp. from the Missourian, and *U. facilis*, n. sp. from the Virgilian. A form from the Desmoinesian is described as *Lasanocrinus altamontensis*, n. sp.

SYSTEMATIC DESCRIPTIONS

Genus UTHAROCRINUS Moore and Plummer, 1938

Synonym.—*Triceracrinus* Bramlette, 1943.

UTHAROCRINUS FACILIS Strimple, n. sp.
Plate 77, figures 11–12, 18–20

Description.—Dorsal cup full, round, and has a very shallow basal concavity. Five IBB form a small pentagonal shaped disk. BB are five large plates curving evenly out of the basal depression. RR are five large plates having strongly outward directed articular facets. Three anal plates occupy the *post.* IR and are in normal placement. Only the first few brachials of the arms are known. $PBrBr_1$ are elongate and axillary.

Ornamentation consists of numerous small spine-like granules. Columnar impression is circular in outline and heavily crenulated.

Measurements.—

	Holotype Mm.	Paratype Mm.
Height for dorsal cup	9.8	7.8 Est.
Width of dorsal cup	4.0	4.0
Width of columnar scar	1.6	—
Maximum diameter of body opening	4.0	—
Length of ant. PBr_1	—	5.2
Maximum width of ant. PBr_1	—	5.0

Remarks.—This species is not readily associated with other forms assigned to the genus because there are no decided protuberances present on any plates of the BB or RR circlets. The dorsal cup could easily be mistaken for a *Perimestocrinus* except that it lacks the deep basal concavity which is supposed to be typical of that genus, and there is a subtle difference in the articular facets of the RR.

Types.—Figured holotype and paratype collected by Allen Graffham. To be deposited in the U. S. National Museum.

Occurrence and Horizon.—Stull shale formation, Shawnee group, Virgilian series, Pennsylvanian; NW ¼ sec. 33, T. 17 S., R. 16. E., 2 miles NW of Melvern, Kansas.

UTHAROCRINUS HABITUS Strimple, n. sp.
Plate 77, figures 13–16

Description.—Dorsal cup is low and has a shallow basal concavity. Five IBB are small normal elements. BB are of modest size and each has a downward directed sharp spine in mid-section. RR are five pentagonal-shaped plates having outward directed articular facets. Ornamentation of RR is most spectacular, consisting of a series of downward directed spines in the area below the outer ligamental area. Three normally placed anal plates occupy the *post.* IR. Each plate is swollen in mid-portion to form a small spine-like node.

All plates are strongly granular appearing. Arms have not been observed. Proximal columnal is round and pierced by a minute round lumen.

Measurements.—

	Holotype Mm.
Height of dorsal cup	4.5
Width of dorsal cup	10.8
Width of proximal columnal	1.8
Maximum diameter of body opening	5.8
Height of basal concavity	1.6

Remarks.—*U. habitus* is close to *U. granulosus* Strimple, 1939, as exemplified by the specimen illustrated on plate 2, figure 2, which is herein designated as the holotype of *U. granulosus.* Principal difference is in the broader, more ornate dorsal cup of *U. habitus.*

Holotype.—Collected by Maurice Mendenhall. To be deposited in the U. S. National Museum.

Occurrence and Horizon.—Wann formation, Ochelata group, Missourian series, Middle Pennsylvanian; the Mound or hill just west of the city limits of Bartlesville, Oklahoma.

UTHAROCRINUS FABULOSUS
Strimple, n. sp.
Plate 77, figures 1–4

Description.—Dorsal cup is high and has exceptionally large and protruded BB. Five small IBB occupy the more or less flattened base. BB are very large and have a small spine-like node in the median portion of each bulbous plate. RR are five pentagonal-shaped elements with pronounced articular facets directed outward.

EXPLANATION OF PLATE 77

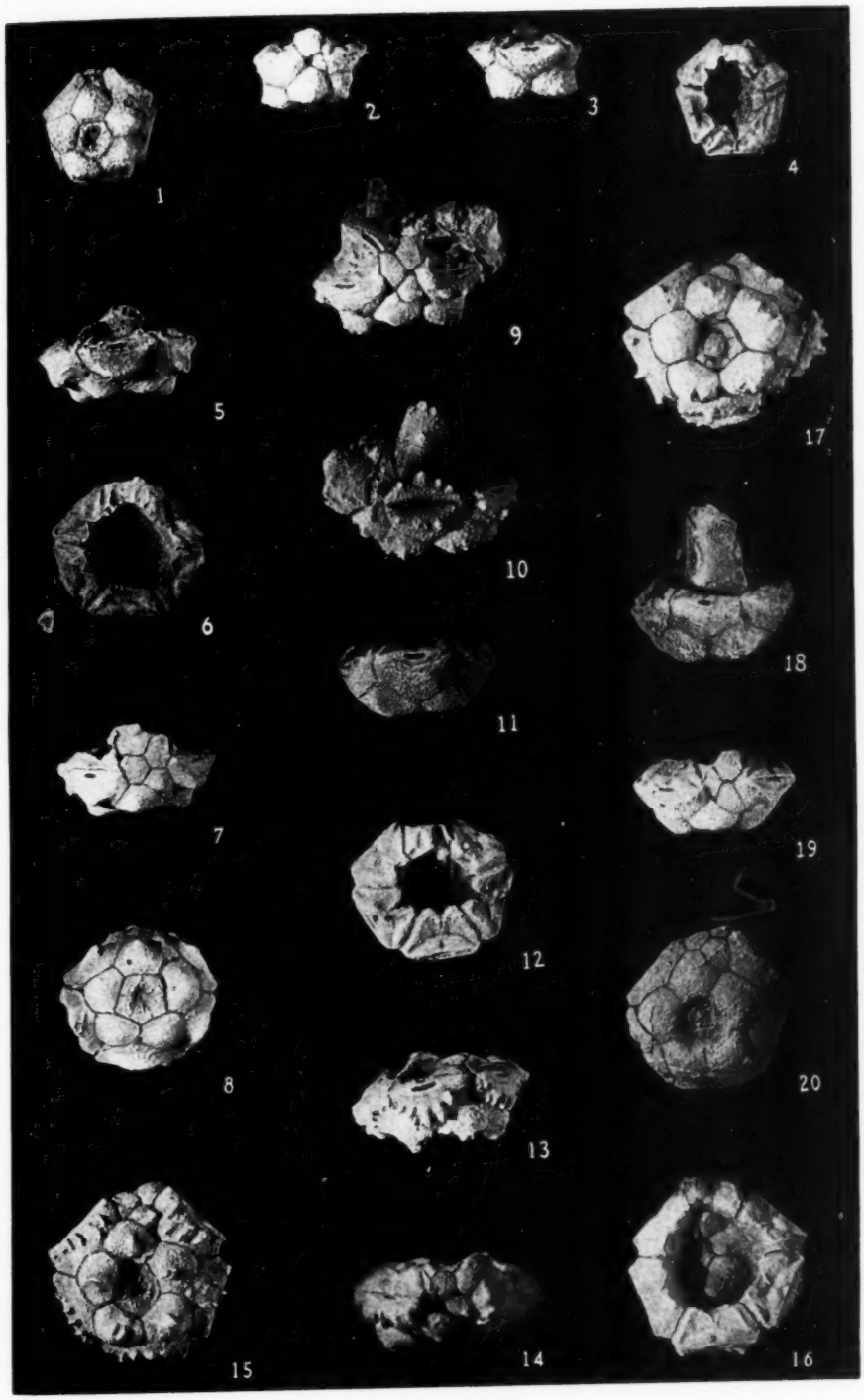
FIGS. *1–4*—*Utharocrinus fabulosus* Strimple, n. sp. Holotype viewed from the base, posterior, anterior and summit. Enlarged 2½ times. (p. 572)

5–8—*Lasanocrinus altamontensis* Strimple, n. sp. Holotype viewed from the anterior, summit, posterior and base. Enlarged 2½ times. (p. 573)

9, *10* and *17*—*Utharocrinus spinosus* Strimple, n. sp. Holotype viewed from posterior, anterior and base. Enlarged 2½ times. (p. 573)

11, *12*, *18–20*—*Utharocrinus facilis* Strimple, n. sp. Figs. *11*, *12*, *19* and *20*, holotype viewed from anterior, summit, posterior and base. Fig. *18*, paratype viewed from the anterior. Enlarged 2⅔ times. (p. 571)

13–16—*Utharocrinus habitus* Strimple, n. sp. Holotype viewed from anterior, posterior, base and summit. Enlarged 2½ times. (p. 572)



Strimple, Pennsylvanian crinoids

There are three anal plates which present an advanced arrangement in that RA has migrated to a posterior position, RX is almost entirely eliminated from the cup and anal X is unusually large.

The dorsal cup is strongly granular appearing. Columnar impression is circular in outline. Arms are not known.

Measurements.—

	Holotype Mm.
Height of dorsal cup	3.7
Width of dorsal cup	7.0
Width of columnar scar	1.0
Maximum diameter of body opening	3.1
Height of basal concavity	0.5

Remarks.—*U. fabulosus* is readily separated from other species assigned to the genus due to the erect nature of the cup, advanced structure of the *post.* IR and the unusually large protruded BB.

Holotype.—Collected by H. L. Strimple. To be deposited in the U. S. National Museum.

Occurrence and Horizon.—Stoner limestone member, Stanton formation, Missourian series, Pennsylvanian; 1 mile west of Wayside, Montgomery County, Kansas.

UTHAROCRINUS SPINOSUS Strimple, n. sp.
Plate 77, figures 9, 10 and 17

Description.—Dorsal cup rather high, bowl-shaped, with base moderately invaginated. IBB are five, extending well out from under the proximal columnal and forming a star-shaped disk. BB are more or less bulbous and each possesses several rather prominent spine-like nodes in median section which are directed downward and outward. RR are wide pentagonal-shaped plates which have a series of three or four prominent nodes marking the arcuate facet found below the outer ligamental area. The centrally placed node is the more pronounced in most instances and each one near the lateral sides is slightly less prominent. Articular facets are directed outward. Three anal plates are in normal arrangement and all have narrow contacts with plates below them.

$PBrBr_1$ are of unequal length. There is a series of strong spine-like nodes along the lower portion of each PBr_1 with the median placed node having the most prominence. The plates are constricted in midsection and flare slightly in upper portions where two or three large nodes are observed.

All sutures are impressed. The entire crown is strongly granular appearing.

Measurements.—

	Holotype Mm.
Height of dorsal cup	3.7
Width of dorsal cup	10.0
Maximum diameter of body opening	5.1 est.
Width of columnar impression	1.2
Length of ant. PBr	5.2
Maximum width of ant. PBr.	4.5

Remarks.—*U. spinosus* can be distinguished from other described species by the rather deep full cup and the prominent, fine, spine-like ornamentation along with a strongly granulose appearance.

Types.—Collected by Melba and Harrell Strimple. To be deposited in the U. S. National Museum.

Occurrence and Horizon.—Unnamed shale 30 feet above the Torpedo sandstone, Ochelata group, Missourian series, Pennsylvanian; 2¼ miles NE of Copan, Washington County, Oklahoma, in abandoned tank dike.

LASANOCRINUS ALTAMONTENSIS
Strimple, n. sp.
Plate 77, figures 5–8

Description.—Dorsal cup is low, with a broad flat base. IBB are small plates forming a pentagonal-shaped disk. BB are of modest size and each has a single, large protuberance in the median portion. RR are distinctive in that there is a flattened, vertically directed area below the outer ligamental area, which culminates in a large node-like protuberance. Articular facets are directed outward. Three anal plates occupy the *post.* IR, anal X resting solidly on the *post.* B, RA is obliquely placed to the right and in turn assists in support of the RX above.

Under magnification the surface is only mildly granular in appearance. Arms are unknown. Columnar scar is round.

Measurements.—

	Holotype Mm.
Height of dorsal cup	3.6
Width of dorsal cup	9.2
Width of columnar scar	1.2
Maximum diameter of body opening	5.1
Height of basal concavity	0.4

Remarks.—*Lasanocrinus altamontensis* is the youngest described species of the genus, the only other known forms being of Morrow age. *L. cornutus* Moore and Plummer and *L. daileyi* (Strimple) have more shallow calices than the present species.

Holotype.—Collected by H. L Strimple. To be deposited in the U. S. National Museum.

Occurrence and Horizon.—Upper part of the Altamont limestone formation, Marmaton group, Desmoinesian series, Pennsylvanian; road cut on eastward extension of 31st Street at southeast edge of Tulsa, Tulsa County, Oklahoma.

MANUSCRIPT RECEIVED NOV. 1, 1949

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JOURNAL OF PALEONTOLOGY, VOL. 24, NO. 5, PP. 575–576, PL. 78, 1 TEXT FIG., SEPTEMBER 1950

ADDITIONAL AMMONOIDS FROM THE MISSISSIPPIAN BARNETT FORMATION OF TEXAS

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ABSTRACT—A collection of Barnett ammonoids that has recently become available for study contains representatives of *Eumorphoceras?*, *Neoglyphioceras*, *Girtyoceras*, and *Cravenoceras*. The single specimen of *Neoglyphioceras* is of a type scarcely if at all known from the formation previously. One of the individuals which belongs in *Girtyoceras* is noteworthy because of its exceptionally large size, and another serves as the basis for a new species.

FOLLOWING the recent publication in this Journal of the Miller-Youngquist report on "The cephalopod fauna of the Mississippian Barnett formation of central Texas," Dr. Benjamin H. Burma sent us for study a small collection (12 specimens) of goniatites which he had assembled from the same beds. All of these came from one of the better-known collecting localities, that is, from about 3 miles southeast of San Saba, Texas, on the road to Chappel (Univ. Texas locality 205-T-24). As might be expected, most of them are referable to species already recorded from the strata which outcrop there, but at least one of them is not. Furthermore, some of the others seem to merit special consideration.

Six of the specimens in this new collection are small, being less than 7 mm. in diameter, and they appear to be immature. Their general physiognomy suggests a relationship to *Eumorphoceras*, but they may well belong in another genus (or in different genera). Unfortunately, we do not yet know enough about immature goniatites to identify most of them very satisfactorily.

One of the other specimens (pl. 78, figs. 4–6) is an internal mold which is only about 14 mm. in diameter and which has a maximum width of conch of only about 5 mm. The umbilicus of this individual is small but open. The outer volution of the conch bears five rounded constrictions which are deep and prominent on the lateral zones, where they form broad shallow sinuses. The surface also bears coarse longitudinal lirae and relatively fine and inconspicuous transverse lines which are approximately parallel to the constrictions. None of the sutures is very clear, but their general shape is shown by the accompanying figure. In all available particulars, this specimen does not seem to differ materially from equal-sized representatives of *Neoglyphioceras subcirculare*

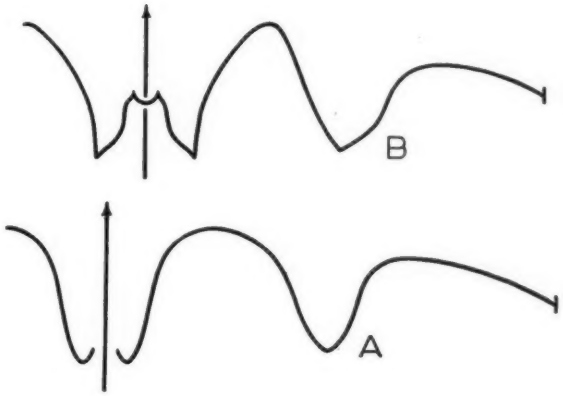

FIG. 1—Diagrammatic representations of external sutures of (A) *Neoglyphioceras subcirculare* (Miller) and (B) *Girtyoceras burmai* Miller and Downs, n. sp. ×9 and ×7½, respectively; based on the specimens illustrated on plate 78 at heights of conch of about 4½ mm. and 5 mm., respectively.

(Miller). That species was originally described from the Meramec? beds of eastern Kentucky, and forms which are closely similar and may be conspecific have been recorded from the Caney of Oklahoma, the Moorefield and Batesville of Arkansas, the upper *Posidonomya* zone (P_2) of northern England, the Mountain limestone of Ireland, the upper Viséan of Belgium and France, zone IIIγ of Germany, and the Viséan of Morocco and northern Algeria. Also, Plummer and Scott (1937, pp. 15, 381, 383, 399) list this species and *N. caneyanum* (Girty), which is probably conspecific, from the Barnett, but peculiarly they do not illustrate or describe any representatives from Texas.

Two of the other specimens in the collection we are studying are referable to *Girtyoceras meslerianum* (Girty). Both are internal molds. One of them, which is about 25 mm. in diameter is septate throughout, and it reveals the nature of its inner as well as its outer volutions. The other is a fragment of an exceptionally large individual with an acute venter, and it manifests that in this species the phragmacone attains a diameter of at least 100 mm. This specimen is imbedded in a block of dark gray limestone which contains two moderate-sized goniatites that do not reveal any trace of sutures but appear to belong in *Cravenoceras* —both have subglobular conchs in which there are deep rounded transverse constrictions, and at least one bears fine but rather prominent transverse lines that are almost straight.

The remaining specimen is also referable to *Girtyoceras*, but it does not appear to belong in any described species. It seems appropriate that it be named in honor of its discoverer, that is, as follows:

GIRTYOCERAS BURMAI Miller and Downs, n. sp.
Plate 78, figures 1–3

The hôlotype of this species is a well preserved internal mold of part of a phragmacone. Its maximum over-all measurement is about 12½ mm., and near its adoral end its conch is about 7 mm. high and 4 mm. wide. The umbilicus is small but is not quite closed. Although the surface of the internal mold is essentially smooth, fine directly transverse lines can be discerned on the narrowly rounded ventral zone. The accompanying illustrations elucidate the general physiognomy of the specimen, the form of its conch, and the shape of the sutures (text-fig. 1B). However, attention should be called to the fact that the conch is expanded orad rather gradually and therefore the holotype consists of at least five volutions, though its diameter is not great. The precise shape of the internal sutures was not ascertained, but clearly they consist of a fairly deep dorsal lobe and on either side of it a rather narrow saddle, a fairly narrow lobe, and a broad lateral saddle which extends to the umbilical lobe.

Remarks.—The conch of this species is considerably narrower than is that of equal-sized representatives of *G. meslerianum* (Girty) [the genotype], its umbilicus is relatively small, and the surface of at least the outer volution of the holotype does not bear sinuous transverse constrictions. *G. limatum* (Miller and Faber) of the Meramec? of eastern Kentucky and possibly the Moorefield of northern Arkansas also has a fairly narrow conch; but its umbilicus is rather large, and the surface of the internal mold bears sinuous transverse constrictions.

Occurrence.—Barnett formation about 3 miles southeast of San Saba, Texas.

Holotype.—State University of Iowa, 2642.

REFERENCE

MILLER, A. K., and YOUNGQUIST, WALTER, 1948, The cephalopod fauna of the Mississippian Barnett formation of central Texas: Jour. Paleontology, vol. 22, pp. 649–671, pls. 94–100.

EXPLANATION OF PLATE 78

The specimens illustrated on this plate are from the Barnett formation about 3 miles southeast of San Saba, Texas. They have been deposited at the State University of Iowa, where their catalogue numbers are 2642 (figs. 1–3) and 1903 (figs. 4–6). These photographs were retouched by Mr. Howard Webster of Iowa City, Iowa.

FIGS. *1–3—Girtyoceras burmai* Miller and Downs, n. sp. Three views of the holotype, ×6.
4–6—Neoglyphioceras subcirculare (Miller). Three views of an internal mold, ×6.

1

4

2

5

3

6

Miller and Downs, Barnett ammonoids from Texas

JOURNAL OF PALEONTOLOGY, VOL. 24, NO. 5, PP. 577–590, PL. 79, 4 TEXT FIGS., SEPTEMBER 1950

A REVISION OF SEVERAL EARLY CAMBRIAN TRILOBITES FROM EASTERN MASSACHUSETTS

ALAN B. SHAW

ABSTRACT—The trilobites of the Hoppin slate, which is exposed at North Attleboro, Massachusetts, and in pebbles on Revere Beach, Massachusetts, are redescribed and refigured. The faunule is analyzed and provisionally correlated with the so-called "*Obolella* zone." The eodiscids of the Hoppin slate and Weymouth formation are discussed and the name *Hebediscus* Whitehouse, 1936, is suppressed in favor of *Dipharus* Clark, 1923.

INTRODUCTION

A REVIEW of the literature on Cambrian faunas of New England reveals that several species from the Lower Cambrian rocks of eastern Massachusetts are inadequately described and poorly illustrated. This is true of the trilobites found at North Attleboro, Massachusetts (text-fig. 1). Inasmuch as a large collection of paratype and topotype material from this locality is available in the collections of the Museum of Comparative Zoölogy, a restudy of the trilobites was undertaken.

It is a pleasure to acknowledge the kindness of Professors P. E. Raymond and P. E. Cloud, who have encouraged and assisted this investigation in every way. To the latter, and to Professor R. R. Shrock, I am also indebted for reading and criticizing the manuscript. My thanks are also due to Professor M. P. Billings, for visiting the locality in North Attleboro and discussing with me the structure of the area. Professor Alonzo Quinn has also aided this study by making available to me the collection of specimens in his institution. My wife, Louise Shaw, has aided me in the technical compilation of the manuscript.

MATERIAL STUDIED

A large portion of the North Attleboro fossils collected by Shaler and Foerste is still available, as well as smaller collections made from the Hoppin slate and the Weymouth formation by H. T. Burr, T. H. Clark, P. E. Raymond, and J. B. Woodworth. The collection of specimens from the Hoppin slate, loaned by Brown University, was incorporated with the other material and, in return, a representative selection of specimens has been deposited with that institution.

DESCRIPTION OF THE HOPPIN SLATE

The Hoppin slate was named by Emerson (1917, p. 36) for several exposures in the vicinity of Hoppin Hill, North Attleboro,

FIG. 1.—Index map of localities mentioned in this article.

Massachussetts. These beds were discovered by N. S. Shaler (1888). Collections of early Cambrian fossils were made by Shaler and described by Shaler and Foerste (1888).

Unfortunately, the most productive beds (Shaler's Station I) are now under water in the Hoppin Hill Reservoir, and only Station II (fig. 1) is still accessible. A brief search was made for more boulders at Station III, but none was found.

The core of Hoppin Hill is a granite correlated with the Dedham granite. At the base of the Hoppin slate lies a massive, partly cross-bedded white quartzite, dipping steeply away from the granite. No apophyses of the granite were seen in the quartzite, but neither were recognizable pebbles of granite noted in the quartzite. Above the quartzite, which seems to be no more than 20 feet thick, lie the red fossiliferous beds of the Hoppin slate. At Station II, which lies in the valley immediately northeast of Hoppin Hill, massive red beds of silty limestone alternate with bands, as much as 3 inches thick, composed largely of comminuted fossil fragments in a red silty limestone matrix. Immediately east of Station II lie highly cleaved red and pale-green slates in which no fossils were found. It is impossible to estimate with any degree of accuracy the thickness of the slate in the valley, but it probably exceeds 100 feet.

On the southwest flank of Hoppin Hill the Hoppin slate is red and highly cleaved. Here, the conglomerate beds of the Pondville arkose, which is regarded as the basal formation of the Carboniferous system, approach to within 50 or 60 feet of the quartzite at the base of the Hoppin. However, this thinning of the Hoppin seems to be local and may be due either to channelling of the top of the Hoppin or to faulting.

The Pondville arkose, which is a quartzite conglomerate at Hoppin Hill, contains well-rounded pebbles of a quartzite much like that at the base of the Hoppin. Above the Pondville lies the Wamsutta formation, which contains red slates almost identical in lithology with the Hoppin. This similarity caused Shaler (1888, map) to map much of the Wamsutta as Cambrian.

ORIGIN OF THE DEPOSITS

At North Attleboro the fossiliferous beds are fine-grained, dark red or maroon silty limestone or calcareous siltstone. The fossils within any stratum show no preferred orientation and are jumbled together in great confusion, but the fossil bands are sharply separated from one another by relatively unfossiliferous beds four to ten inches thick. There seems to have been some sorting according to size, but it was not perfect. Hand specimens tend either to contain *Strenuella* cranidia in large numbers or a few *Strenuellas* and rare eodiscids. No specimen in the collections contains a concentration of eodiscids. Sorting was also effective among the shells of *Hyolithes* and *Salterella*, which are found in some blocks crowded together as closely as is possible, to the virtual exclusion of the trilobites. This is especially notable in specimens from Shaler's Station I, which is now under water.

The eodiscids and the pygidia of *Strenuella strenua* are not common. A special search was made for them during preparation of the material, but even in the deposits made up almost entirely of trilobites these small forms are rare, and it seems that they have been winnowed out. It is possible that the absence of the eodiscids alone might be due to original scarcity, but unless winnowing has taken place the pygidia of *Strenuella* should be present in something like the numbers in which the cranidia are found, but no isolated pygidia were found. The free cheeks of *S. strenua* that have been recovered are all large and heavy (fig. 3).

Thus, it seems that these deposits were subjected to some sorting, which tended to concentrate the heavier fragments, but which did not remove all of the minute forms. It seems probably that the Hoppin slate was deposited in shallow water near a low-lying land. The silt content of the rock is high, and a specimen leached of its calcium carbonate is reduced to a soft siltstone that can be crumbled in the fingers. This suggests that the deposits were laid down close enough to shore so that clastics entered the area in high percentage, while at the same time lime was not completely masked.

The lack of conglomerates in the Hoppin indicates that the land probably did not stand very high at the beginning of Cambrian onlap in this area.

COMPOSITION AND CORRELATION OF THE HOPPIN FAUNA

The Hoppin slate contains an early Cambrian fauna characteristic of the North Atlantic region (the Caledonian geosyncline) (Grabau, 1936, pp. 73 ff.). The most significant dating elements are *Strenuella* and *Salterella* (s.s.), both of which are common in the lowest Cambrian rocks.

It was impossible to make a precise count of the specimens in the collections, but the percentage composition of the fauna seems to be about as follows: *Strenuella strenua* comprises about 45 per cent of the specimens; *Salterella* and *Hyolithes* together, about 40 per cent; the inarticulate brachiopods, about 10 per cent; and the remaining 5 per cent is divided among the eodiscids, gastropods, and olenellids. The eodiscids are represented by about two dozen specimens, the gastropods, by less than a dozen, and the olenellids are known only from a unique specimen described by Shaler and Foerste and now, unfortunately, missing.

On the Cambrian Correlation Chart (Howell and others, 1944) the Hoppin slate and the Weymouth formation are grouped as one and correlated with the entire "*Olenellus* zone" and the uppermost part of the "*Bonnia* zone." Some revision of this placement now seems possible.

A comparison of the faunas of the Hoppin slate and the Weymouth formation, as represented by the Burr Collection in the Museum of Comparative Zoölogy, shows that the only common trilobite genus is *Strenuella*. As will be discussed below, the species *Weymouthia nobilis* (Ford), 1872, which was formerly thought to be common to both formations, is now believed to be restricted to the Weymouth formation.

The greatest difference between the two faunas is in the development of the olenellids, which are abundant in the Weymouth and lacking in the Hoppin. This difference may be due to ecologic variation or to selective preservation, but the total absence of olenellids in the Hoppin, even as fragments, combined with the presence of abundant inarticulate brachiopods lends support to the interpretation advanced here that the Hoppin is a preolenellidian formation, older than the Weymouth, and assignable to the so-called "*Obolella* zone." Because of the facies differences between the two formations, however, this correlation must be regarded as provisional.

SYSTEMATIC PALEONTOLOGY

In reviewing the material from the Hoppin slate, all usable fossils were set aside, but it soon became obvious that several of the species were either entirely lacking or poorly represented. This was especially true of the gastropods. Therefore, it was decided to present a discussion of the trilobites alone.

Order OPISTHOPARIA Beecher, 1897
Suborder PTYCHOPARIIDA Richter, 1933
Superfamily ELLIPSOCEPHALIDEA Richter, 1933
Family ELLIPSOCEPHALIDAE Matthew, 1887
Genus STRENUELLA Matthew, 1888
STRENUELLA STRENUA (Billings), 1874
Plate 79, figures 2–14

Agraulos strenuus BILLINGS, 1874, Paleozoic Fossils, Geol. Survey Canada, vol. 2, pt. 1, pp. 71–72, fig. 41.
Strenuella strenua MATTHEW, 1888, Royal Soc. Canada Proc. and Trans. for 1887, vol. 5, sec. 4, p. 131.
Ptychoparia mucronatus SHALER and FOERSTE, 1888, Harvard Coll. Mus. Comp. Zoölogy Bull., vol. 16, no. 2, p. 37, pl. 2, figs. 21a–d.
Agraulos strenuus WALCOTT, 1891, U. S. Geol. Survey 10th Ann. Rept., pt. 1, p. 653, pl. 97, figs. 1, 1a, 1b (?), 1c.
Agraulos strenuus var. *nasutus* WALCOTT, 1891, op. cit. p. 654, pl. 97, figs. 2, 2a–c.
Ptycroparia mucronata GORHAM, 1905, Roger Williams Park Mus. Bull. 9, pl. 2, figs. 21a–d.

Species not assigned to S. strenua

Strenuella strenua SHIMER, 1907, Am. Jour. Sci., 4th ser., vol. 23, no. 135, pp. 199–201.

Billings described *Agraulos strenuus* as follows:

> Head (without moveable cheeks) irregularly quadrangular, broadly rounded in front. Glabella rather strongly convex, conical, variable in its proportional length and width, either smooth or with several obscure impressions on each side representing the glabellar furrows; neck segment with a strong triangular projection backwards; neck furrows all across but usually obscurely impressed. In some specimens the front of the head has a thick, convex marginal rim separated from the front of the glabella by a narrow groove. In others this rim is scarcely at all developed. The eyes, shown by the form of the lobe, appear to have been semi-annular and about one-third the length of the head. The surface appears to be smooth.

It will be noted that Billings included in his species the forms with "a thick, convex marginal rim," which were the basis of Walcott's variety *nasutus* (figs. 5, 7–9). The material at hand indicates that the thickening of the margin is a feature ap-

pearing in the larger cranidia and is due to maturity or geronticism in the animal; therefore, the variety is not to be regarded as valid.

Billings' description is excellent, but some additions may be made to it:

General outline of test elongate oval (fig. 13). Cephalon nearly semicircular. Facial sutures curve around rather long palpebral lobes and continue with but slight inward curve to anterior margin; with but slight outward curve to rear margin. Both frontal limb and posterior limbs depressed below level of fixed cheeks so that sutures curve downward from palpebral lobes (figs. 7–9).

Dorsal furrow distinct in some specimens, but more commonly glabella is set off from fixed cheeks by its convexity alone. Fixed cheeks ordinarily smoothly rounded; less commonly there is a subtriangular elevated field on upper surface, bounded by furrow on posterior limb, dorsal furrow, and ocular ridge-palpebral furrow. Such an area appears on a specimen figured by Walcott (1891, pl. 97, fig. 1a).

Ocular ridges common on internal molds (figs. 2, 6); they curve backward to palpebral lobes, which are situated far back on cranidia so that anterior edge of lobe is opposite midlength of glabella. Palpebral lobes set off by palpebral furrows.

Free cheeks bear bluntly rounded genal spines. Eyes elevated above general level of cheeks, which are depressed. Doublure of cheek irregularly striated parallel to margin (fig. 3).

Shaler and Foerste (1888, p. 38) mention the recovery of three complete specimens, of which one, with a damaged head, was figured. Two of these, including the figured specimen (figs. 11–13), are still in the collection, although the unfigured specimen is now so badly abraded that it is of little use. The specimens have 11 and 13 thoracic segments, and both are internal molds. Each thoracic segment bears a median node, those on the posterior segments being the most prominent. An external mold of the rear part of a thorax is preserved and indicates that spines rose about 1½ mm. above the axial lobe and were directed backward at an angle of about 30° from the vertical. Distal part of pleura flexed sharply downward.

Shaler and Foerste did not find the pygidium of this trilobite, but excavation of the two complete specimens has revealed py-

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EXPLANATION OF PLATE 79

FIG. *1*—Shaler's Station II at North Attleboro. Viewed from the southeast.

2–14—*Strenuella strenua* (Billings), 1874. All specimens are from North Attleboro. *2*, Internal impression of cranidium, showing impression of occipital spine. ×2. MCZ No. 4818. *3*. Plasticine squeeze of large free cheek. ×1. MCZ. No. 4822. *4*. Axial portion of thoracic segment with median spine. Internal impression. ×2. MCZ. No. 4821. *5*. Largest well-preserved cranidium recovered. Internal impression, showing thickened rim. ×1. MCZ No. 4826. *6*. Internal impression of small cranidium with eye lines and three glabellar furrows. Right side abraded. ×2½. MCZ No. 4820. *7*. Fragment of internal impression of large cranidium showing prominent thickened rim. ×1. MCZ No. 4828. *8*, *9*. Plasticine squeeze from natural external mold showing thickened rim. ×2. MCZ No. 4815. *10*. Fragment of medium sized cranidium showing well-developed occipital spine. Internal impression. ×2. MCZ No. 4819. *11–13*. Paratype entire of *Ptychoparia mucronatus* figured by Shaler and Foerste. Cranidium is damaged. Internal impression. MCZ No. 4827. *11*. ×1½. *12*. ×2½. 13. ×2. *14*. Internal impression of medium-sized cranidium. ×2. MCZ No. 4817. (p. 579)

15–18—*Dipharus attleborensis* (Shaler and Foerste), 1888. *15* and *18* from pebbles on Revere Beach. *16* and *17* from North Attleboro. *15*. Rubber cast made from natural external mold of cranidium. ×8. MCZ No. 4830. *16*. Internal impression of cranidium. ×5. MCZ No. 4813. *17*. Plasticine squeeze of natural external mold of pygidium. ×5. MCZ No. 4829. *18*. Holotype of *Dipharus insperatus* Clark, 1923. ×12. MCZ No. 1693. (p. 586)

19–23—*Eodiscus* (*Serrodiscus*) *bellimarginatus* (Shaler and Foerste), 1888. All specimens from North Attleboro. *19*. Internal impression of axial lobe of largest pygidium recovered. Paratype described by Shaler and Foerste. ×2. MCZ No. 4811. *20*. Internal impression of cephalon. ×1½. MCZ No. 4818. *21*. Internal impression of pygidium. ×1½ MCZ No. 4824. *22*. Rubber cast made from natural external impression of large cephalon. ×3. MCZ No. 4816. *23*. Rubber cast made from damaged natural external mold of pygidium. Four ventral teeth are visible. ×3. MCZ No. 4823. (p. 582)

24—*Weymouthia nobilis* (Ford), 1872. Plesiotype. ×5. Weymouth formation. MCZ No. 246. (p. 584)

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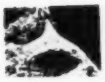
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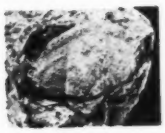
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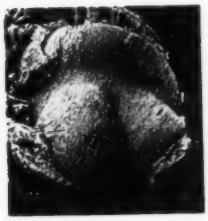
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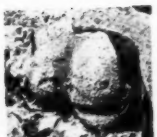
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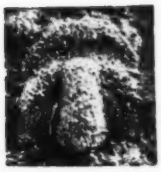
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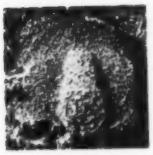
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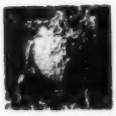
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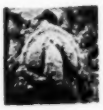
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Shaw, Massachusetts Cambrian Trilobites

gidia in their normal vertical position (fig. 12). The pygidium is a simple round plate reminiscent of those found in the Olenellidae and Paradoxididae. It seems to be composed of two segments, however, for there is a pair of furrows close to the anterior margin. The pygidium figured by Walcott is more transverse and has a much squarer posterior outline than those discovered on the North Attleboro specimens, and it may not belong to this species.

Suborder REDLICHIIDA
Richter, 1933
Superfamily REDLICHIIDEA
Richter, 1933
Family OLENELLIDAE
Vogdes, 1893
Genus and species undet.

Paradoxides walcotti SHALER and FOERSTE, 1888, Harvard Coll. Mus. Comp. Zoölogy Bull., vol. 16, no. 2, p. 36, pl. 2, fig. 12.
Olenellus walcotti WALCOTT, 1891, U. S. Geol. Survey 10th Ann. Rept., pt. 1, p. 636, pl. 88, fig. 2
Olenellus?? walcotti WALCOTT, 1910, Smithsonian Misc. Coll., vol. 53, no. 6, p. 341, pl. 24, fig. 11

Shaler and Foerste recorded the presence in their collection from Station II of a single small cephalon, which they named *Paradoxides walcotti*. However, in 1891 Walcott pointed out the similarity between *P. walcotti* and immature specimens of *Elliptocephala asaphoides* Emmons, 1844. In 1910, when Walcott revised the Olenellidae, he again assigned this unique specimen to *Olenellus*, but with great reservation; he said "there is not sufficient material to identify it with *Elliptocephala asaphoides* Emmons, nor to decide that it is not identical."

The original specimen is now lost, and although a careful search was made for further evidences of the presence of the Olenellidae at North Attleboro, none was found, and the record of this family must rest solely upon the report of Shaler and Foerste.

Order AGNOSTIDA Kobayashi, 1935
Superfamily EODISCIDEA
Kobayashi, 1935

The eodiscids have been studied by several workers during the past few years, but the resulting classifications have been widely divergent. This is due in part to the difficulty of exchanging information during the war years, but principally it stems from a fundamental difference in point of view.

The first point of disagreement is on the relationship between the eodiscids and the agnostids. Whitehouse (1939, p. 181) and Rasetti (1945, 1948) have regarded the eodiscids as an independent order, Eodiscida or Eodiscidea, thus separating the eodiscids from the agnostids. On the other hand, Kobayashi (1935), the Richters (1941), and Westergård (1946) have grouped the agnostids and eodiscids together.

Kobayashi classified the eodiscids under the Agnostida, first as the superfamily Eodiscidea (Kobayashi, 1935, p. 81) and more recently as the superfamily Dawsonidea (Kobayashi, 1943, p. 38; 1944, p. 44). This latter term seems to be an unnecessary duplication of the name Eodiscidea inasmuch as both include the genus *Eodiscus*. The Richters (1941, p. 17) consider the eodiscids and the agnostids as families in the superfamily Agnostidea and have been followed in this usage by Westergård (1946, p. 20), but this arrangement does not seem to leave a sufficient number of levels of classification among which the agnostids may be distributed. Therefore, in this paper Kobayashi's grouping has been followed.

My studies of the eodiscids have been limited to specimens of only eight species, from seven genera and subgenera. Therefore, it would be presumptuous to attempt any large-scale revision of the group, which, as Rasetti has pointed out, should be based upon the study of actual specimens and not upon old and inaccurate literature. However, some of the species studied do permit some modification of the Kobayashi and Richter classifications; these are indicated briefly below.

The examination of *Dipharus attleborensis* (Shaler and Foerste), 1888, and of its larval stage, *D. "insperatus"* Clark, 1923, has led me to the conclusion that the agnostids and eodiscids are indeed descended from the same stock. Therefore, I must disagree with those who place the agnostids and eodiscids in separate orders.

On a lower taxonomic level, the study of *Eodiscus* (*Serrodiscus*) *bellimarginatus* (Shaler and Foerste), 1888, has suggested

that *Paradiscus* Kobayashi, 1943, with *Microdiscus speciosus* Ford, 1872, as genotype, which was included in *Serrodiscus* by the Richters, may be a valid subgenus of *Eodiscus*.

As a result of these studies, the following distribution of a portion of the eodiscids is suggested:

Order AGNOSTIDA Kobayashi, 1935
Superfamily EODISCIDEA Kobayashi, 1935
Family EODISCIDAE Raymond, 1913 (synonym: Weymouthiidae Kobayashi, 1943)
Genus *Eodiscus* Raymond, 1913
Subgenus *Serrodiscus* R. & E. Richter, 1941
Subgenus *Paradiscus* Kobayashi, 1943
Genus *Weymouthia* Raymond, 1913
Family PAGETIIDAE Kobayashi, 1935 (synonym: Hebediscidae Kobayashi, 1943; Dipharidae Kobayashi, 1943)
Genus *Dipharus* Clark, 1923 (synonym: *Hebediscus* Whitehouse, 1936

Family EODISCIDAE Raymond, 1913

Eodiscidea with narrow, sharply tapered glabella and rhachis, both of which occupy most of the length of the shield. Glabella smooth or faintly furrowed and commonly shorter than rhachis. Rhachis with many segments, but these are effaced in some species. Pleural lobes of both shields smooth. Tubercles commonly present on rim of cephalon.

Genus EODISCUS Raymond, 1913

This genus is commonly cited as *Eodiscus* Matthew, 1896, but a study of Matthew's article will show that he did not use the name *Eodiscus* generically, but merely mentioned that Hartt had placed the name on some of the labels in the latter's collection. Matthew summarily rejected the name *Eodiscus* and described the species now regarded as the type of *Eodiscus* as *Microdiscus schucherti*. The name was not used in a generic sense until Raymond's revision of the Eodiscidae in 1913. Therefore, the name must be *Eodiscus* Raymond, 1913, with the genotype, by original selection, *Microdiscus schucherti* Matthew, 1896.

Subgenus SERRODISCUS R. & E. Richter, 1941

Subgenotype.—Eodiscus (*Serrodiscus*) *serratus* R. & E. Richter, 1941

The Richters (1941, p. 23) made the following diagnosis of *Serrodiscus:*

> A subgenus, which is separated from *Eodiscus* (*Eodiscus*), with the type *E.* (*E.*) *schucherti* Matthew, through the following characteristics of the pygidium: Pygidium long. Axial lobe long with very many (at least 8+X to 14+X) rings; broader than a pleural lobe. The rim bends over into the development of generally downward-directed teeth.

They included the following five species in the subgenus:

E. serratus R. & E. Richter, 1941; *E. silesius* R. & E. Richter, 1941; *E. insularis* (Matthew), 1899; *E. bellimarginatus* ((Shaler and Foerste), 1888; and *E. speciosus* (Ford), 1872.

In 1943, Kobayashi chose *Microdiscus speciosus* as the genotype of his new genus *Paradiscus*, which, as will be discussed below, is here recognized on paleogeographic as well as paleontologic grounds as a valid subgenus of *Eodiscus*.

EODISCUS (SERRODISCUS) BELLIMARGINATUS (Shaler and Foerste), 1888

Plate 79, figures 19–23

Microdiscus belli-marginatus SHALER and FOERSTE, 1888, Harvard Coll. Mus. Comp. Zoölogy Bull., vol. 16, no. 2, p. 35, pl. 2, figs. 19, 19a.
Microdiscus belli-marginatus VOGDES, 1890, U. S. Geol. Survey Bull. 63, p. 125.
Microdiscus bellimarginatus WALCOTT, 1891, U. S. Geol. Survey 10th Ann. Rept., pt. 1, p. 630, pl. 81, figs. 2, 2a–b.
Microdiscus bellicinctus MATTHEW, 1896, Am. Geologist, vol, 18, no. 1, p. 29.
Microdiscus belli-marginatus GORHAM, 1905, Roger Williams Park Mus. Bull. 9, pl. 2, figs. 19, 19a.
Eodiscus belli-marginatus RAYMOND, 1913, Ottawa Naturalist, vol. 27, p. 103, fig. 7.
Eodiscus bellimarginatus CLARK, 1923, Boston Soc. Nat. History Proc., vol. 36, no. 8, p. 476.
Eodiscus (*Serrodiscus*) *silesius* R. & E. RICHTER, 1941, Senckenberg. naturf. Gesell. Abh. 455, p. 26, pl. 1, figs. 11–14, pl. 4, fig. 60.
Eodiscus bellimarginatus KOBAYASHI, 1944, Imp. Univ. Tokyo Jour. Fac. Sci., sec. 2, vol. 7, pt. 1, p. 52, pl. 1 fig. 5b (only)

Diagnosis.—Eodiscus (*Serrodiscus*) *bellimarginatus* differs from other species in the subgenus by having six to eight ventral teeth on the rim of the pygidium.

Description.—Cephalon semicircular to subtriangular. Glabella tapering slightly, but commonly conical due to flattening of the specimen; glabella occupies one-third of cephalic width. Dorsal furrow well-defined. Occipital ring with median node; produced backward into a short spike in some specimens. Cheeks show no sign of eye-lobes or facial sutures and are confluent by a very narrow ridge in front of glabella. Rim well marked except where occipital ring overhangs; narrower at rear than laterally and widens slightly in front of glabella. Five to seven small tubercles on each side of cephalon, becoming obsolete anteriorly. Genal angles produced into short spines, which are rarely preserved.

Thorax not known.

Pygidium approximately same size and shape as cephalon, with conical axial lobe about nine-tenths as long as whole shield and marked by seven or more segments. Each segment behind articulating ring bears small median tubercle, which becomes obsolete posteriorly. Pleural lobes smooth, inside and out, confluent posteriorly. Brim well defined, convex, and of even width; underside bears six to eight ventrally directed teeth, which Matthew (1899, p. 75) suggested may have fitted into the tubercles on the rim of the cephalon and served to lock the cephalon and pygidium together when the trilobite was enrolled.

The following measurements, in millimeters, were obtained from three cephala:

	1	2	3
Length (incl. occipital ring)	3.5	5.1	5.5
Glabellar length (incl. occipital ring)	2.6	4.1	4.1
Maximum width	3.4	6.8	7.0
Maximum glabellar width	1.2	2.1	—
Maximum height of glabella above base of cephalon (±0.2 mm.)	—	—	1.8

Three pygidia have the following dimensions, in millimeters:

Length	3.5	—	5.0
Anterior width	3.2	5.8	7.6
Length of axial lobe	3.2	3.5	—
Anterior width of axial lobe	1.2	1.8	2.2

The largest pygidium, a fragment described by Shaler and Foerste, is still in the collection and is illustrated in figure 19. It has a length of more than 8 mm. Another, partly exfoliated pygidium shows that the test was approximately 0.1 mm. thick.

Holotype.—USNM No. 18329 (fide Walcott, 1891).

Specimens studied.—13 cephala, eight pygidia.

Comparison with other species.—In erecting the subgenus *Serrodiscus* the Richters assigned to it the five species listed earlier. Of these, they believed *E. speciosus* and *E. bellimarginatus* lacked ventral teeth on the pygidium, whereas the other three were known to have them. Matthew's *E. bellimarginatus* mut. *insularis* was raised to the status of a species on this basis. However, *E. bellimarginatus* does have ventral teeth (fig. 23). When this fact is realized, all differences between *E. bellimarginatus* and *E. silesius* R. & E. Richter seem to disappear, and the latter is here regarded as a junior synonym of *E. bellimarginatus*. No specimens of *E. bellimarginatus* mut. *insularis* (Matthew) have been available, but they should be studied to determine whether that mutation may not also be a synonym of *E. bellimarginatus*.

With the recognition that *E. bellimarginatus* possesses ventral teeth, all species of *Serrodiscus* are shown to bear them except *E. speciosus* (Ford). This species is also exceptional among those assigned by the Richters to *Serrodiscus*, in being the only one found in the Appalachian geosyncline. Therefore, because of the difference in the pygidial structure and because of the paleogeographic distribution, it seems best to recognize *Paradiscus* Kobayashi, 1943, with *Microdiscus speciosus* Ford, 1872, as genotype, as a valid subgenus of *Eodiscus*, distinguishable from *Serrodiscus* by the absence of ventrally directed pygidial teeth.

It seems probable that in earliest Cambrian time the barrier between the Appalachian and Caledonian geosynclines was not present and that the ancestral stock from which both *Eodiscus* (*Serrodiscus*) and *Eodiscus* (*Paradiscus*) developed was dispersed into both geosynclines. A similar parallelism may be seen between the genera *Dipharus* and *Pagetides*, the former developing in the Caledonian and the latter in the Appalachian geosyncline. Analogous examples can be found among the Olenellidae of the two regions.

Genus WEYMOUTHIA Raymond, 1913

Synonyms.—Delgadoia Vogdes, 1914: *Delgadodiscus* Kobayashi 1935; *Alemtejoia* Kobayashi, 1943.

Genotype by original selection.—Agnostus nobilis Ford, 1872.

Clark (1923) recorded the presence of *Weymouthia nobilis* (Ford) in pebbles of the Hoppin slate that he collected from Revere Beach, Massachusetts (text-fig. 1). An examination of his specimens has led me to the conclusion that they are the pygidia of *Dipharus attleborensis*, inasmuch as they are identical with those described by Cobbold in 1931. Therefore, *Weymouthia* is not present in the Hoppin slate fauna. However, the plesiotype of *W. nobilis* found in the Weymouth formation and described by Raymond has not been figured photographically, so a discussion of it is included here.

Weymouthia includes Eodiscidae in which the exterior surface of both shields is smooth. Traces of dorsal furrows are retained on the interior surface. *Weymouthia* was regarded by the Richters (1941) as a subgenus of *Eodiscus*, but the effacement of the test seems to be a great enough modification to warrant the recognition of *Weymouthia* as a separate genus.

Three generic names, other than *Weymouthia*, have been applied to the smooth Eodiscidae. The first was *Delgadoia*, proposed by Vogdes (1917, pp. 27, 81) for the four species described by Delgado as having eyes and facial sutures; Vogdes selected *Microdiscus caudatus* Delgado, 1904, as the genotype. Subsequently, Kobayashi (1935, p. 112) chose the same species as genotype of *Delgadodiscus*. More recently Kobayashi (1943) has erected a third genus, *Alemtejoia*, with *M. souzai* Delgado, 1904, as genotype.

The Richters (1941 p. 30), have studied Delgado's four species and have decided that *M. souzai* and *M. caudatus* are the same and that both are assignable to *Weymouthia*. Therefore, all three of the alternative names must be suppressed as junior synonyms of *Weymouthia*.

WEYMOUTHIA NOBILIS (Ford), 1872
Plate 79, figure 24

Agnostus nobilis FORD, 1872, Am. Jour. Sci., 3d ser., vol. 3, p. 421, figs. 1, 2.
Agnostus nobilis WALCOTT, 1886, U. S. Geol. Survey Bull. 30, p. 150, pl. 16, fig. 7.
Microdiscus? nobilis WALCOTT, 1891, U. S. Geol. Survey 10th Ann. Rept., pt. 1, p. 591.
Agnostus nobilis WALCOTT, 1891, op. cit., p. 629, pl. 80, fig. 5.
Microdiscus? nobilis VOGDES, 1892, Am. Geologist, vol. 9, pp. 380, 383.
Agnostus nobilis VOGDES, 1893, California Acad. Sci. Occ. Paper 4, p. 265.
Weymouthia nobilis RAYMOND, 1913, Ottawa Naturalist, vol. 27, p. 102, figs. 15, 16.
Weymouthia nobilis RAYMOND, 1920, Connecticut Acad. Arts and Sci. Mem. 7, p. 139, fig. 35.
Weymouthia nobilis SHIMER and SHROCK, 1944, Index Fossils of North America, p. 619, pl. 252, fig. 16, Wiley, New York.
Weymouthia nobilis KOBAYASHI, 1944, Imp. Univ. Tokyo Jour. Fac. Sci., sec. 2, vol. 7, pt. 1, p. 67, pl. 1, fig. 16.

Specimens assigned with hesitation to the species

Weymouthia nobilis KAIER, 1917, Vidensk. selsk. Kristiania Forh. 1916, 2 Bd., no. 10, p. 28, pl. 3, figs. 12, 12a–b.
Weymouthia nobilis COBBOLD, 1931, Geol. Soc. London Quart. Jour., vol. 87, p. 466, pl. 38, figs. 17–22.

Diagnosis.—Weymouthia nobilis differs from other species in the genus by having the rim of the longer shield tuberculate, and in having the same shield elongate rather than triangular in outline.

Orientation.—As in the case of the smooth agnostids, some doubt has arisen regarding the orientation of the weymouthiid test. The Richters say that it is difficult to tell the head of *W. caudata* from the tail, but they conclude that the longer, more pointed shield is the pygidium. In the figured plesiotype of *W. nobilis* the longer shield is believed to be the cephalon because of the presence of tubercles upon its rim. Tubercles are not found on the pygidia of other eodiscids.

Description.—Cephalon (larger shield) ovate longitudinally, convex, faintly rimmed. Central posterior portion of cephalon overhangs rim and conceals it. Rim distinct and concave in exfoliated specimens; in the plesiotype rim bears four small tubercles on each side. Anterior tubercle nearly obsolete, and it is probable that only last three were visible on outer surface of test.

Thorax with three segments. Pleura sharply geniculate at about their midpoint. Axial lobe equal in width to combined width of pleural lobes.

Pygidium (smaller shield) less elongate than cephalon, but equally convex. Rim seems to have been virtually unmarked on exterior of shield but well defined and concave on interior mold. Central portion of shield overhangs rim in same manner as corresponding part of cephalon.

Axial lobe of pygidium still faintly discernible on exfoliated plesiotype, although it does not appear in the photograph. On specimens figured by Cobbold, dorsal furrow marks off entire axial lobe, which reaches to, but not across, rim.

Measurements of plesiotype are: Length of cephalon 3.20 mm., length of pygidium 2.67 mm., maximum width of cephalon 3.30 mm., maximum width of pygidium 3.25 mm., average width of cephalic rim 0.29 mm., average width of pygidial rim 0.27 mm.

Holotype.—Lost.

Plesiotype collected from slates in the Weymouth formation: MCZ No. 246.

Remarks.—It is probable that more than one species is included in *Weymouthia nobilis* as it is here constituted, but because of the insufficient material at hand it is deemed inadvisable to erect new species at this time. However, some of the differences may be indicated.

Inasmuch as Ford's holotype is lost the description given above is based largely upon the plesiotype figured in this paper. First, it should be noted that the plesiotype does not have the transverse striations described and figured by Ford, but this may be due entirely to the exfoliated condition of the plesiotype. Furthermore, the plesiotype has fewer tubercles on its rim than were figured by Ford. In this latter respect the British specimens, which have seven tubercles, are closer to Ford's original figure than is the Weymouth specimen, which has only four. It is possible that this difference is of specific value, but until this can be proved it seems wiser to regard the species as variable in this feature.

Probably of more biologic significance is the presence in the British specimens of a well marked dorsal furrow, the same furrow being practically obsolete in the Weymouth specimen.

The pygidium figured by Kaier seems very probably to belong to this genus, but it differs from both the British and American specimens and may represent still another new species.

Family PAGETIIDAE Kobayashi, 1935

This family includes Eodiscidae having eyes or eye-lobes and, in some genera, proparian facial sutures. There are three thoracic segments in the Early Cambrian *Dipharus* Clark, 1923, and *Pagetides* Rasetti, 1945, and there are two in the Middle Cambrian *Pagetia* Walcott, 1916. The thorax is not known in the Middle Cambrian *Aulacodiscus* Westergård, 1946.

The Pagetiidae seem to represent a single phyletic group. The genera which possess both eyes and facial sutures, such as *Dipharus, Pagetides,* and *Pagetia,* are probably representative of the root stock, whereas a genus such as *Aulacodiscus,* which according to Westergård has eye lobes but fused facial sutures, seems to represent an intermediate stage in the development of blind eodiscids. The fact that such intermediate forms are present in the Middle Cambrian suggests that the blind eodiscids may be polyphyletic.

It is possible that separate subfamilies ought to be erected to receive the genera with two and three thoracic segments, but this does not seem to be necessary at present.

Genus DIPHARUS Clark, 1923

Synonym.—*Hebediscus* Whitehouse, 1936.

Genotype.—*Ptychoparia attleborensis* Shaler and Foerste, 1888 (= *Dipharus insperatus* Clark, 1923).

Pagetiidae having a long, inflated, conical glabella, flat triangular fixed cheeks, and a wide flat brim. Three thoracic segments. Proparian facial sutures that are not fused.

Inasmuch as *Dipharus insperatus,* the selected genotype of *Dipharus,* is probably a larval stage of "*Ptychoparia*" *attleborensis* Shaler and Foerste, 1888, the genotype of *Hebediscus, Hebediscus* must be suppressed in favor of the earlier name *Dipharus.* It is unfortunate that the generic name should have been first applied to an immature specimen, but that fact alone in no way invalidates the name *Dipharus.*

DIPHARUS ATTLEBORENSIS (Shaler and Foerste), 1888

Plate 79, figures 15–18; text-figures 2, 3

Ptychoparia attleborensis SHALER and FOERSTE, 1888, Harvard Coll. Mus. Comp. Zoölogy Bull., vol. 16 no. 2, p. 39, pl. 2, fig. 14.
Ptychoparia attleborensis WALCOTT, 1891, U. S. Geol. Survey 10th Ann. Rept., pt. 1, p. 649, pl. 95, fig. 2.
Ptycroparia attleborensis GORHAM, 1905, Roger Williams Park Mus. Bull. 9, pl. 2, fig. 14.
Weymouthia nobilis CLARK, 1923 (not Ford, 1872), Boston Soc. Nat. History Proc., vol. 36, no. 8, p. 477.
Dipharus insperatus CLARK, 1923, op. cit. p. 478, figs. 1, 1a.
Hebediscus attleborensis WHITEHOUSE, 1936, Queensland Mus. Mems., vol. 11, pt. 1, p. 80, footnote 25.
Hebediscus attleborensis KOBAYASHI, 1944, Imp. Univ. Tokyo Jour. Fac. Sci., sec. 2, vol. 7, pt. 1, pp. 61, 69.
Dipharus insperatus KOBAYASHI, 1944, op. cit., pp. 62, 69, pl. 1, fig. 12, pl. 2, fig. 19.

Description.—Cranidium convex, with prominent glabella. Glabella conical,

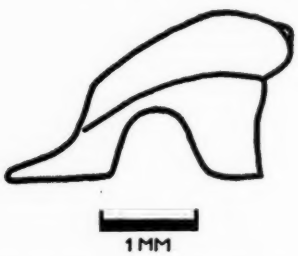

FIG. 2.—Restoration of the lateral aspect of the cranidium of *Dipharus attleborensis*, based upon several camera-lucida sketches.

rounded anteriorly, marked in some specimens by traces of three pairs of glabellar furrows. No dorsal furrows, the glabella being distinct by reason of its convexity. Occipital furrow obsolete. Rear of glabella overhangs posterior edge of cranidium and bears small median tubercle. Sides of glabella nearly straight on exterior of test (fig. 15), but interior molds retain bilobed glabella of the immature stage (fig. 16), which will be discussed below.

Fixed cheeks flat, prominent, triangular, slightly wider than glabella; they slope downward anteriorly and are separated from frontal limb and posterior limbs by abrupt, almost vertical slopes. Cheeks not confluent in front of glabella. Traces of eyelines seem to be present on one or two internal molds.

Palpebral lobes prominent rounded continuations of fixed cheeks; they are broken away in most specimens. Eyes lie slightly forward of midlength of glabella and at midlength of cranidium.

Frontal limb long, comprising nearly one-third of cranidial length; flat or slightly concave, rimless. Posterior limbs short, triangular, depressed well below level of fixed cheeks and subequal in width to them.

Anterior branch of facial suture descends almost vertically from front of palpebral lobe to edge of cranidium. Posterior branch curves backward in sigmoid flexure almost to genal angle (text-fig. 2). Surface of both shields smooth.

Thorax not known.

Three internal molds from North Attleboro and one external mold each from North Attleboro and Revere Beach represent the pygidium of this species. Pygidium equal in size to cephalon, tumid. Rim narrow, flat, well defined on outside of test, but concave and poorly marked on interior. Pygidia greatly resemble shields of *Weymouthia nobilis*.

An immature stage of *D. attleborensis*

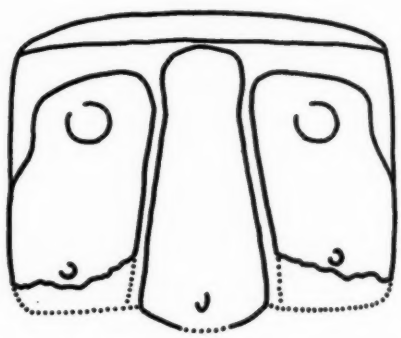

FIG. 3.—Outline sketch of the protaspid of *Dipharus attleborensis*.

seems to be represented by the unique specimen that has been designated the holotype of *Dipharus insperatus* Clark, 1923 (text-fig. 3, and fig. 18). The shield is rectangular. Glabella well defined by deep dorsal furrow, occupies seven-eighths of length of shield, tapers slightly. Anterior quarter of

glabella separated by shallow, transverse furrow into small knob reminiscent of anterior glabellar lobe so common in most Agnostidea. Posterior portion of glabella rises rearward and bears small median node, as in adult cranidium. Similarity of the glabella of this small specimen and exfoliated adult glabellae (fig. 16) has been mentioned above.

"The eyes are situated on conical elevations of remarkable height, standing nearly twice as high as the glabella above the dorsal furrow. Each fixed cheek bears a very small tubercle near its posterior margin" (Clark, 1923, p. 479).

Cheeks tumid, rising nearly to level of glabella; they drop off abruptly in front of eyes and glabella into flat, rimless frontal limb. Excavation of the holotype reveals that anterior margin of specimen is straight, not curved as shown in Clark's figure.

Evidence of facial sutures is inconclusive; they may have taken a proparian course, such as Clark described, but the granular texture of the test replacement (silica?) makes any determination difficult.

Specimens studied: eight cranidia and four pygidia from North Attleboro; five cranidia and one pygidium from Revere Beach, and holotype of *D. insperatus* (MCZ No. 1693) from Revere Beach.

Holotype of *Ptychoparia attleborensis* Shaler and Foerste, 1888; USNM No. 18332 (fide Walcott, 1891).

Remarks.—Cobbold (1931, p. 465) was the first to suggest that *Dipharus* Clark might be a larval form of *Hebediscus* Whitehouse. He has been followed in this opinion by Whitehouse (1936, p. 81), R. & E. Richter (1941, p. 18), and Westergård (1946, p. 21), but all of them have suppressed *Dipharus* in favor of the later name *Hebediscus*, which is an unjustifiable procedure.

Recently Kobayashi (1943, p. 39; 1944, p. 62) revived *Dipharus* and added a new species, *D. peculiaris*, based upon the specimen figured by Cobbold (1931, pl. 3, fig. 6) from Comley. He grouped *Dipharus* and *Hebediscus* together in a new family, the Dipharidae. However, there is little doubt that *D. peculiaris* is the immature form of *D. cobboldi*, and therefore invalid.

Of the genera represented in the Hoppin slate, "*Olenellus*," *Strenuella*, *Serrodiscus*, and "*Hebediscus*," the larval stages of the first two are known and do not resemble *Dipharus*. Of the remaining genera it seems far more likely that *D. insperatus* should be grouped with the prominent-eyed "*Hebediscus*" than with the blind *Serrodiscus*. Furthermore, *Serrodiscus* has not been reported from the Comley beds where *Dipharus* and "*Hebediscus*" are also associated.

Comparison with other species.—*D. cobboldi* (Resser), 1936 does not differ from *D. attleborensis* in any way that I can determine, but since I have not seen specimens of the former, I do not formally propose to suppress Resser's name at this time. As mentioned above, *D. peculiaris* Kobayashi, 1943, is probably a larval stage of *D. cobboldi* and as such does not merit a separate specific name.

D.? annio (Cobbold), 1910, is here assigned to the genus with hesitation. The species agrees with *D. attleborensis* in general appearance of the cranidium and was regarded by Cobbold as congeneric with *D. cobboldi*. However, it differs from *D. attleborensis* in its tumid brim and pointed glabella. *D.? annio* was assigned by the Richters (1941, p. 18) to *Strenueva* R. & E. Richter, 1940, and by Kobayashi (1944, p. 69) to *Strenuella*. But it differs from *Strenueva* in the shape of the fixed cheeks, the proparian course of the facial suture, and the general structure. It differs from *Strenuella* in the same respects, as well as the shape of the pygidium.

An analysis of Dipharus attleborensis.—The collections from North Attleboro and Revere Beach include thirteen cranidia of *D. attleborensis* as well as the holotype specimen of *D. "insperatus"* Clark. Of the adult specimens, nine are well enough preserved to yield the numerical data analyzed below.

While the number of specimens is admittedly small it is felt that the results are worthy of presentation because of the significance of this species in the study of the eodiscids.

All measurements were made under a binocular microscope fitted with a micrometer ocular, which allowed measurements with an accuracy of 0.025 mm. The data were recorded in terms of the actual divisions of the micrometer scale and the com-

putations carried out without conversion into millimeters. Conversion was made only when the regression formulae had been derived; this eliminated as much as possible of the errors introduced by rounding. However, all the data in table 1 are presented in millimeters. Text-figure 4 illustrates the dimensions measured.

Table 2 lists the correlations which have statistical significance. Several other combinations were analyzed, but because of the small size of the sample the regressions could have been due to chance alone and are not recorded.

Position of Dipharus *in the Agnostida.*—Those students who would separate the Agnostidea and Eodiscidea stress the fact that the glabellar and rhachial structure of the agnostids is not found in any other group of trilobites. They assert that it is only the small size, reduced thorax, and isopygous shields, all of which may have developed as an adaptation to the same environment, that prompted their grouping in the first place. They regard these points of similarity as of less importance than the differences between the two.

In the light of these arguments *Dipharus* assumes importance because it is a genus that exhibits the bilobed glabella of the agnostid, while still being clearly assignable to the eodiscids. Similar glabellar structure is found in *Aulacodiscus bilobatus* Wester-

TABLE 1—MEASUREMENTS OF NINE CRANIDIA OF *Dipharus attleborensis* (SHALER AND FOERSTE), 1888. SPECIMENS WITH THE PREFIX *A* ARE FROM NORTH ATTLEBORO, MASSACHUSETTS; THOSE WITH THE PREFIX *R* ARE FROM PEBBLES ON REVERE BEACH, MASSACHUSETTS

Specimen	Total Length	Glabellar Length	Maximum Height	Palpebral Width	Height of Eye Lobe	Glabellar Width	Posterior Cranidial Width
	A	B	C	D	E	F	G
A1	3.25	2.24	1.81	3.20	—	1.39	3.63
A2	2.99	2.03	1.12	2.45	0.53	1.01	—
A3	2.72	1.87	1.55	2.40	0.69	0.53	2.50
A4	2.61	1.81	1.17	2.45	0.48	—	2.66
A5	2.19	1.81	—	2.08	—	—	—
R1	2.19	1.60	1.07	2.03	0.32	0.96	2.45
R2	2.08	1.55	1.07	2.03	0.53	0.53	—
R3	2.08	1.55	0.64	1.81	0.27	0.80	2.29
R4	1.44	1.07	0.69	1.17	0.21	0.59	1.60

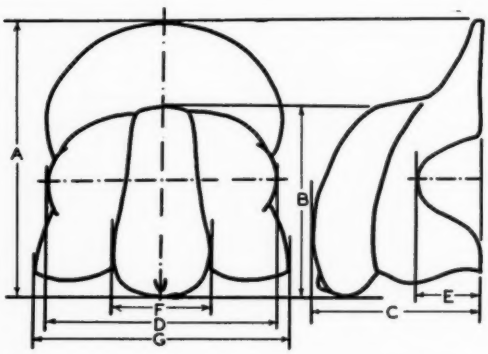

FIG. 4.—Measurements taken upon the cranidium of *Dipharus attleborensis*. Letters correspond to those on Tables *1* and *2*. A=Total cranidial length. B=Glabellar length. C=Maximum height. D=Palpebral width. E=Height of palpebral lobe. F=Posterior glabellar width. G=Posterior cranidial (posterolateral) width.

TABLE 2—COEFFICIENTS OF CORRELATION FOR THE CRANIDIAL FEATURES OF *Dipharus attleborensis*. LETTERS IN THE FORMULAE CORRESPOND TO THOSE IN TABLE 1. σ=STANDARD ERROR OF ESTIMATE. N=NUMBER OF SPECIMENS IN SAMPLE

Regression Formulae	σ	N
A=1.59B−0.34	0.14	9
B=0.59A+0.31	0.09	9
C=0.56A−0.21	0.21	8
C=1.61E+0.35	0.13	7
D=0.96A−0.12	0.15	9
E=0.51C−0.10	0.07	7

gård, 1946, even in the adult. Possibly this is an atavistic feature, but it seems to point to an ancestral connection between the agnostids and eodiscids.

Therefore, it seems most natural that the agnostids and eodiscids should be grouped together in a single order, the Agnostida, because they seem to have been derived from a common parent stock, but the obvious differences between the two groups, especially those of the pygidium, which were emphasized by Rasetti (1948, p. 6), makes imperative the separation of the two groups into separate superfamilies.

Genus undet.

Microdiscus cf. *M. helena* BURR, 1900, Am. Geologist, vol. 25, p. 47.
Microdiscus sp. GRABAU, 1900, Boston Soc. Nat. History Occ. Paper 4, pt. 3, p. 671, pl. 33, fig. 3.
Cobboldites gracilis KOBAYASHI, 1943, Imp. Acad. Tokyo Proc., vol. 19, no. 1, p. 38.
Cobboldites gracilis KOBAYASHI, 1944, Imp. Univ. Tokyo Jour. Fac. Sci., sec. 2, vol. 7, pt. 1, pp. 49–50, 52.

Burr's type specimen is in the collection of the Museum of Comparative Zoölogy, and because of the comments made in this paper on other eodiscids of eastern Massachusetts it is discussed for the sake of completeness.

Examination of the specimen, which comes from slates of the Weymouth formation, shows that Grabau's restoration is almost wholly inferential. The specimen is so badly weathered that it cannot be identified beyond stating that it probably was an eodiscid. Burr said that it was a pygidium, but the finer features are so much deteriorated that even this determination is open to question.

The trivial name "*gracilis*," which Kobayashi proposed, will remain applicable to Burr's type, but inasmuch as the specimen is not identifiable, no generic assignment can be made.

The specimen is not figured, for an illustration would show nothing.

Holotype.—MCZ No. 4656.

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MANUSCRIPT RECEIVED OCT. 24, 1949

JOURNAL OF PALEONTOLOGY, VOL. 24, NO. 5, PP. 591–593, PL. 80, 1 TEXT FIG., SEPTEMBER 1950

AN UPPER CAMBRIAN PLEOSPONGID (?)

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ABSTRACT—A small pleospongid-type organism is described from two specimens from Upper Cambrian beds in Texas, a new genus and species being named. It is typified by an irregular canal system radially arranged from a central cavity. Insufficient knowledge of the organism leaves its proper classification in doubt.

MR. BEN DONEGAN, a student at the University of Texas, collected a small sponge-like fossil from Upper Cambrian limestone at the Camp San Saba section in the Llano Uplift of Texas. Mr. Donegan estimated that the material came from the uppermost Morgan Creek member of the Wilberns formation; the presence of a glabella of the trilobite *Drumaspis* in the matrix of the sample confirmed this. A subsequent search of these beds by the writer revealed another better-preserved specimen on a bedding plane about two feet below the top of the Morgan Creek member associated with the trilobites *Drumaspis* and *Idahoia*.

The specimens consisted of weathered centrally depressed elevations partially exposed on bedding plane surfaces of limestone shown by thin sections to be glauconitic, fragmental, and of clastic origin. Granular calcite has replaced the skeletal framework. Molds of the exteriors were prepared and the specimens then cut into transverse, tangential and longitudinal thin sections which were stained with malachite green. This has darkened the glauconitic limestone filling the canals of the organism, leaving the replaced skeleton light. Both specimens were completely destroyed in constructing the necessary slides.

SYSTEMATIC DESCRIPTION

Phylum PORIFERA
Class PLEOSPONGIA (?)
incertae sedis
Genus WILBERNICYATHUS Wilson, n. gen.

Definition.—Cup- or crater-shaped organisms almost 15 mm. in diameter with an irregular root-like base and downward tapering central cavity surrounded by radial, branching partitions seemingly without plate-like connecting structures between them. Perforation of partitions and inner wall of central cavity unknown. Outer wall porous but seemingly not differentiated. Spicules apparently lacking, structures being replaced by granular calcite.

Genotype.—*Wilbernicyathus donegani* Wilson, n. sp.

WILBERNICYATHUS DONEGANI
Wilson, n. sp.
Plate 80, figures 1–7

Species about twice as wide as high with regular unannulated walls. The diameter of the higher portion of the central cavity (weathered open in specimen 1) is approximately twice the wall thickness or about half the total diameter which is 12 or 13 mm. Central cavity tapers downward; nature of its base is uncertain but it probably ends abruptly and does not extend completely through to the substratum. The second specimen is more depressed and the central cavity is not weathered out. The dissimilarities in upper body form and the irregular nature of the base of both specimens indicate that probably shape is inconstant in the species.

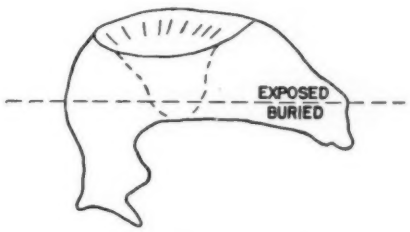

FIG. 1.—*Wilbernicyathus donegani* Wilson, n. sp., free hand drawing, X3, of axial longitudinal section, type, CW-350.

Specimen 2 possesses a weathered outer surface showing what are probably large irregularly spaced pores. This outer wall forms a wide lateral extension of one quadrant and may represent exothecal material. Thin sections show no distinct outer wall layer. The main body wall (intervallum ?) is thick and composed of 50 or 60 poorly defined radially arranged partitions (parieties ?) best seen on dorsal view of specimen 2. These probably formed the walls of a complex canal system. Transverse sections both high and low show that most partitions branch and that few extend completely from the central cavity to the periphery. The partitions are not as wide as the interspaces (canals ?). Longitudinal and tangential sections show unoriented wall structure. No certain evidence exists of any plate-like connections between partitions.

Specimen 2 shows a central thickening of the partitions possibly to form a coherent inner wall. Outer rings formed in the same manner also exist on this specimen. The fossils were too small to permit examination of the interior lining of the central cavity; construction of transverse thin sections precluded grinding the necessary longitudinal section. Microscopic examination of the partitions under high power shows them to be composed of small grains of calcite with no spicular structure.

Type.—CW-350; specimen 1, represented by 4 thin sections and a rubber squeeze and plaster cast of the original specimen. Location: somewhere in upper beds of the Morgan Creek member of the Wilberns limestone, Camp San Saba, 300 yards upstream from the old ford of San Saba River, 11 miles south of Brady, McCulloch County, Texas. Supplementary specimen: CW-351, specimen 2, represented by a plaster cast of exterior and a transverse thin section of uppermost cup. Location: 2 feet below top of the Morgan Creek member of the Wilbers formation, same section as above. All specimens are in the personal collection of the writer.

Biological Affinities.—The material is insufficient to furnish complete morphological information, but the absence of a theca and the indefinite arrangement, branched condition of many of the partitions are considered proof that the organism is not a coral.

Wilbernicyathus may be compared with the lithistid sponge *Archeoscyphia*. Dr. Virgil Barnes of the Texas Bureau of Economic Geology furnished the writer with a calcified specimen of this genus from the Ellenburger group. Transverse thin sections of the two forms resemble each other, but that of *Archeoscyphia* shows this sponge to have a much larger central cavity and thinner wall with relatively unbranched and thinner partitions. That *Wilbernicyathus* bears no trace of the spicular lattice-work of *Archeoscyphia* cannot be considered an important difference. Archeoscyphids do not show such when preserved in calcite as are the *Wilbernicyathus* specimens. There is, however, no external indication in *Wilbernicyathus* of the axially directed columns formed by the spicules of the Ordovician genus.

The writer is grateful to Dr. Vladimir J. Okulitch, who examined some of the illustrations and text of this paper, for pointing out the possible relation of *Wilbernicyathus* to pleospongids such as *Dendrocyathus* Okulitch 1947. Gross body form, size of central cavity, apparent lack of spicules, and the shape, size, branching, and relative thickness of the partitions are similar in the two forms. In addition to the considerable difference in geologic age between known pleospongids and *Wilbernicyathus*, the apparent absence of tabulae or synapticulae and the lack of proof as

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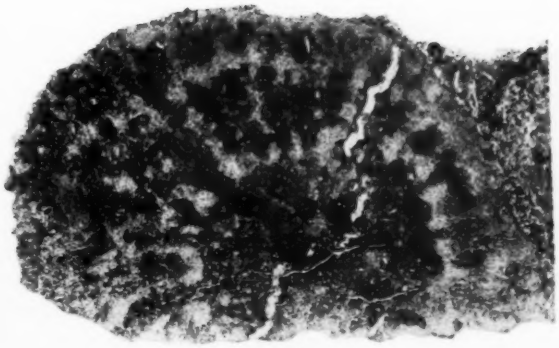
EXPLANATION OF PLATE 80

FIGS. *1–7*—*Wilbernicyathus donegani* Wilson, n. sp. *1, 2*, dorsal and lateral views, about ×3, of weathered surface of specimen 2, CW-351. *3*, thin section, ×5½, of uppermost portion of specimen 2 (right half, fig. *1*) showing rings formed of thickened partitions. *4*, detail of exterior of specimen 2, (area right center, fig. *1*), ×7, showing porous nature of outer wall. *5, 6*, oblique-lateral and dorsal views, ×3, of plaster cast of specimen 1, type, CW-350. *7*, transverse section, ×10, of type, CW-350, left side of text figure about halfway up from bedding plane surface, relatively lower in cup than section in fig. *2*.

1



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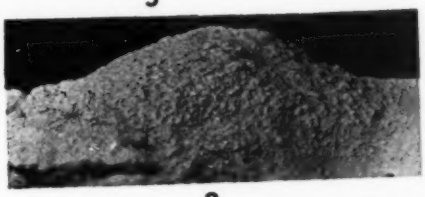

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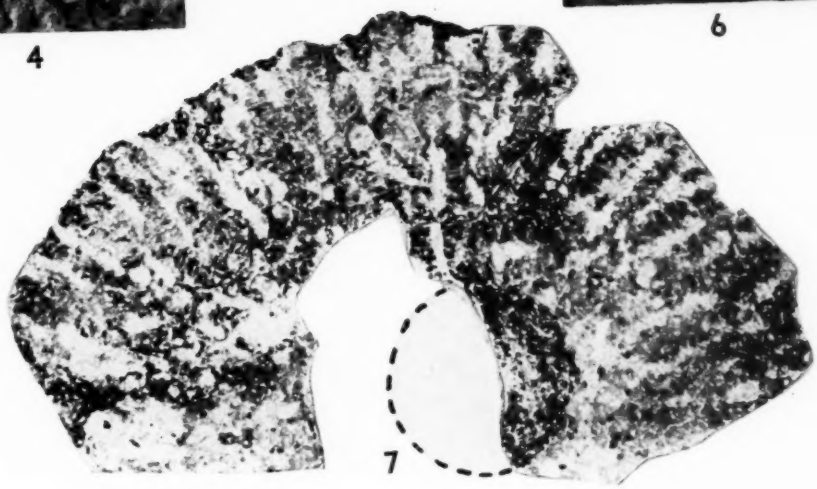

7

Wilson, Upper Cambrian pleospongid

to the porous nature of the partitions and central cavity lining cast doubt on the assignment of *Wilbernicyathus* to this well known group of Lower Cambrian sponges.

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CRETACEOUS FISH EGG CAPSULE FROM KANSAS

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ABSTRACT—Fossil, sharklike egg cases, at first widely identified as plants, have been known from American and European localities for many years. The specimen described here is the first from Cretaceous strata in Kansas and the youngest of its spirally-twisted kind reported from anywhere in the world. Associated with this capsule are remains of land plants, but both capsule and plants may have been entombed in a slightly brackish water site, as inferred by comparison with similar American and European occurrences. The fossil plants suggest an early Upper Cretaceous age.

KANSAS FISH EGG CAPSULE AND OTHERS

The late Dr. E. E. Slosson, author of "Creative Chemistry," once pithily remarked of scientists, "A man may not find what he is looking for, but he never finds anything unless he is looking for something." Paleontologists, characteristically, are always looking for something, sometimes finding the piece they are seeking to fit into the jigsaw pattern of past life. Not infrequently, however, they uncover an unexpected and, for a time, a baffling piece of the puzzle. Of such is the fish egg capsule described here, the first from the Cretaceous rocks of Kansas and the youngest of its particular kind[1] known from any part of the world, the latest previously reported being from the early Lower Cretaceous Wealden strata of England and Europe.

Recently, in rounding up the late Lower Cretaceous and early Upper Cretaceous plant collections in the U. S. National Museum, with the hope of finding characteristic species that would help to determine the Lower Cretaceous-Upper Cretaceous boundary, I came upon a small lot accumulated by the late Prof. E. W. Berry and donated in 1947 to the Museum by the Johns Hopkins University. This material was collected in 1924 by Dr. A. C. Tester, of the State University of Iowa, from grayish to pinkish Cretaceous shales in sec. 3, T. 16 S., R. 9 W., Ellsworth County, and sec. 34, T. 23 S., R. 22 W., Hodgeman County, Kansas. The fossil plants in the collection include fragments of quillworts, ferns, coniferous twigs, cone scales, seeds, and dicotyledonous leaves. Undeterminable fragments of mollusks and insects are also present. Among this assemblage I found, in the Ellsworth County lot, the specimen (fig. 3) that represents a group of objects originally regarded as parts of plants, but now believed to be egg cases of sharklike fishes.

The preserved portion of the specimen measures 6 cm. in length and the greatest diameter of the body part, 13 mm. The beak, as in all these objects, is nearly entire and is relatively broad as compared with the broken tail. Remnants of a narrow ribbon or membrane are present along the margins. Three widely spaced spiral lines cross the body of the specimen, indicating only a slight twist of the capsule, in contrast with some of the more twisted specimens from the Pennsylvanian (fig. 2). No carbonaceous material is present, the specimen being an impression only.

As I have none of the originally described specimens of the species of these capsules at hand, and as I am disinclined to become involved with their now somewhat complicated nomenclature, I shall refrain from making an attempt to segregate genera and species and also from naming the specimen

[1] My first fishing venture in this connection (1946), in which I described some Jurassic, Cretaceous, and Oligocene chimaeroid capsules, has netted fruitful results, enabling the identification by P. S. Warren (1948) of a new species from Cretaceous strata in Alberta, Canada. Dr. J. Brookes Knight, of the U. S. National Museum, while perusing a publication in 1947 in search of other information, accidentally found the description of still another specimen, hitherto overlooked, namely, that reported by Stanislaus Meunier (1891) as a plant, *Cycadospalix virei*, from Jurassic outcrops near Verdun France. Recently, Wilhelm Bock (1949) described an unusual specimen from the Triassic of the Connecticut Valley.

from Kansas, although it probably represents a new species and may, if more specimens become available, eventually serve as a stratigraphic and age indicator.

The reader, interested in the historical development of the ideas concerning these fossils, will find the subject adequately summarized by Kidston (1885), Moysey (1910), and Crookall (1932). Generic names, it appears, were invented right and left, as follows:

1828. *Palaeoxyris*. Brongniart, Ann. Sci. Nat., vol. 15, p. 456.
1852. *Palaeobromelia*. Ettingshausen, Abh. k. k. Geol. Reichsanst., vol. 1, pt. 3, p. 3.
1860. *Sporlederia*. Stiehler, Bromeliacean der Vorwelt, p. 8. Preoccupied by a genus of mosses.
1865. *Vetacapsula*. Mackie, Geol. Nat. Hist. Rep., London, vol. 1, p. 79.
1870. *Spirangium*. Schimper, Paleont. Veg., vol. 2, p. 514.
1884. *Fayolia*. Renault and Zeiller, Compte Rendu Acad. Sci. Paris, vol. 98, p. 1393.
1884. *Gyrocalamus*. Weiss, Steink. Calam. II, p. 152.
1885. *Spiraxis*. Newberry, Ann. N. Y. Acad. Sci., vol. 3, p. 219. Preoccupied by a genus of mollusks.
1887. *Prospiraxis*. Williams, U. S. Geol. Survey Bull. 41, p. 86.
1924. *Scapellites*. Pruvost, Ann. Soc. Sci. Bruxelles, vol. 42, p. 150.

One species from the Carboniferous of England was called *Carpolithes helicteroides* Morris in 1840.

The current tendency seems to be to accept *Palaeoxyris* as the name for a large group of these capsules with spiral markings, although the name is obviously a misnomer, the fossils having no relationship whatever with the monocotyledonous plant called *Xyris* or yellow-eyed grass. *Spirangium* is appropriate and descriptive but lacks the sanction of priority.

The fossils, particularly those assigned to *Palaeoxyris*, may occur singly or in groups, up to seven or more, arranged radially around a common center. Satisfactory illustrations of single specimens can be seen in papers by Lesquereux (1880, pl. 75, figs. 11–15), Kidston (1886, pl. 1), Renault and Zeiller (1888, pl. 41, figs. 5–9; pl. 42, figs. 1–6), Moysey (1910, pls. 24–27), Chabakov (1927, text-figs. 1–3), Pruvost (1930, text-figs. 1–3; pl. 2), and Demanet and Van Straelen (1938, text-figs. 127–129; pl. 144). Radially arranged groups have been illustrated by Ettingshausen (1852, pls. 1, 2), Schenk (1871, pl. 19(40), fig. 13; pl. 20(41), Schimper (1872, pl. 80, fig. 5), and Crookall (1932, pl. 2, figs. 2–4).

Kidston presented illustrations and the synonymy of *Palaeoxyris* to 1885 and called attention to the apparently allied genus *Fayolia*. He considered the then current opinion, that the fossils are seed vessels, as not proved, but had no other explanation. By the time of Moysey's summary, the opinion, first broached by Schenk (1867, p. 204; 1888, p. 188) and then elaborated and illustrated by Renault and Zeiller (1888, p. 1022; 1890, p. 369), that the fossils derive from fishes, had been widely accepted. Moysey gives a readable review of the entire situation up to 1910, discussing anatomical features, distinguishing characters, and geological occurrences of the several genera and species. He entertains the comparison between the spirally marked fossils and the somewhat similar egg cases of living, sharklike, cestraciont fishes, with the possibility that the fossils may represent fishes in the ancestral stock from which cestracionts and chimaeroids originated.

Crookall's 1932 paper summarizes succinctly the information he accumulated during several years' study of these fossils. His list of the many plants and animals or derivatives thereof, to which these objects have been likened, is both interesting and impressive, as is also his epitome and evaluation of the views regarding affinities held by the chief investigators of these egg cases.

The prevailing opinion is that these objects represent the egg cases of sharklike fishes that entered brackish or even fresher waters to spawn. Before proceeding to comparisons with the egg capsules of probably related living fishes, some details of the fossils must be noted. The spiral lines are conspicuous features in most of these fossils, except the group called *Vetacapsula*, which has only lengthwise striations. A collarette with an entire or fringed border may be partly preserved in some specimens of *Palaeoxyris* (fig. 2) and *Fayolia* (Renault and Zeiller, 1888, text-fig. 1, p. 27, and pl. 41, figs. 6, 9). As there is almost every degree of twisting to be seen in large suites of these

fossils, questions arise as to its origin and significance, whether the twisting antedated or postdated the laying and hatching, and whether the number and breadth of spiral bands indicate different species of fishes. Whatever was the fact, if, in imagination, we unwind a spiralled specimen by taking one or two turns in reverse as the situation requires, the result is an elongated, spindle-like object, with several ridges or applications running lengthwise over the body. Extending outward for a centimeter or more from the body is the thin ribbonlike membrane or collarette, the plane of which divides the capsule into dorsal and ventral valves. In this plane, also along the body, may or may not be a row of spiracles or breathing pores. Thus, the entire capsule, with its somewhat wider head or beak portion, the body proper, the narrower tail portion, and the lateral membranous flange or collarette, becomes remarkably comparable to the capsules of living species of *Chimaera* (Brown, 1946, pl. 39, figs. 5, 6). One scarcely twisted specimen (fig. 1), from Mazon Creek, Ill., is particularly chimaeroid in essential features.

Comparisons can also be drawn with the spiral-banded egg capsules of the elasmobranch group that includes the Port Jackson or cestraciont sharks, *Heterodontus philippi* and *H. galeatus*. These egg cases, however, lack the conspicuous beaks and tails displayed by the fossils. They perhaps resemble more closely the problematic Devonian *Spiraxis* described by Newberry.

The geologic range of these egg capsules extends from the late Devonian (if *Spiraxis* be admitted as authentic) to the early Upper Cretaceous. Most of the species have been described from European occurrences. In North America, screwlike forms called *Spiraxis major* and *S. randalli* were described by Newberry (1884) from late Devonian marine or brackish water strata in northern Pennsylvania and southern New York. To these was added a third species, *S. interstrialis* Stainier, from Devonian rocks in Belgium. The relationship of these species seems to be with the *Palaeoxyris* group of capsules. The specimen called *S. bivalvis* Ward (1887, p. 14, pl. 1, fig. 3) from Paleocene strata northwest of Glendive, Mont., is an inorganic concretion, whose apparent spiral markings are only hardened layers representing the original bedding of the enclosing rock.

By far the most prolific source of *Palaeoxyris* in North America is the notable concretionary zone in the Pennsylvanian rocks of the Mazon Creek area, about 50 miles southwest of Chicago, Ill. From these strata Lesquereux (1870, p. 464, pl. 27, figs. 10–13) reported *P. prendeli*, *P. appendiculata*, and *P. corrugata*. Ten years later (1880) he renamed and refigured these species as *Spirangium*. Lesquereux regarded these objects as capsular bodies of uncertain affinity, particularly not with *Xyris*, and described their surfaces as " . . . formed of a thin pellicle, and by its compression, the spiral lines of both sides are marked upon it, thus forming, by their crossings, a trellis of more or less enlarged rhomboidal divisions." Some more or less entire fishes and numerous fish teeth, some sharklike, have been taken from the Mazon Creek deposits (Newberry and Worthen, 1870), but which of these, if any, are organically related to the egg capsules is unknown.

Two capsules of *Palaeoxyris* (*Spirangium*) from Mazon Creek are here figured (figs. 1, 2) for comparison with the specimen from Kansas. It will be noted that figure 1 displays little, if any, spiral twist. Figure 2, on the other hand, is that of a strongly twisted specimen. Moreover, this fossil, on the left-hand side near the base of the beak and also on both sides of the tail, retains fragments of the collarette. This, so far as I know, has never been noted before on any specimen called *Palaeoxyris*. Crookall's table (1932, p. 137), in the column headed "Ornamentation," says of *Palaeoxyris*, "simple ridges as in Rays." The Mazon Creek *Palaeoxyris*, therefore, simulates the European *Fayolia*, with its collarettes, but differs in lacking the so-called "spine scars," which may not be spine scars, but breathing pores.

Suggestive questions and hints for further investigation come to mind in regard to these egg cases.

As only minute amounts of phosphate have been found in a few of the impressions, a specimen containing remains of the embryo should be sought. It may yield a satisfactory amount of phosphate to confirm the suspected animal origin of the fossils.

Teeth and other associates of these objects, besides the usual plants, should be looked for in the hope of effecting a more precise classification.

Absence of a carbonaceous film on all egg capsules so far investigated is considered evidence against a plant origin. This may not be true; hence any such film found should be examined carefully for diagnostic chemical and cuticular features.

The radial arrangement of egg cases, as shown especially by *Palaeoxyris* from the Wealden (Lower Cretaceous), needs explanation. Perhaps one female fish, that probably laid only one egg or at most two at any given time, found a seaweed or other suitable support for attaching her egg and was imitated by others, who also found the same support likewise suitable for their eggs. Thus, whorls of egg capsules could form.

Whether the number of spiral lines, indicating original longitudinal ridges or plications, can be used to distinguish genera and species, remains to be seen.

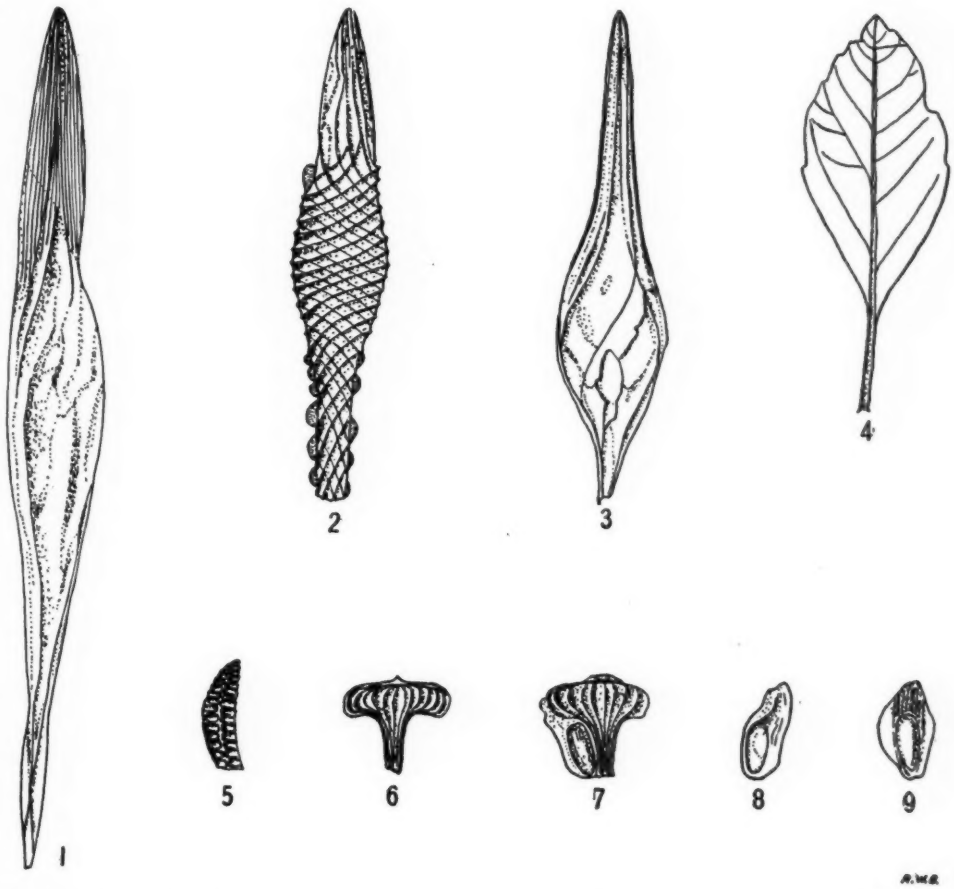

FIG. *1–9—1*, Only slightly distorted fish egg capsule from the Pennsylvanian on Mazon Creek, Ill. *2*, spiralled specimen from Mazon Creek, showing remnants of collarette on left side at base of beak and on both sides of tail. *3*, Slightly spiralled specimen from the Cretaceous of Ellsworth County, Kansas, showing only remnants of a very narrow lateral flange or collarette. *4*, Undetermined dicotyledonous leaf. *5*, *Isoetites serratus* Brown, ×2. *6–9*, *Dammarites borealis* (Heer) Seward. Cone scales and seeds of a tree with araucarian affinities. *7*, shows a seed in place on a cone scale. All figures natural size except Fig. *5*, ×2.

PLANTS ASSOCIATED WITH THE KANSAS EGG CASE

In 1925, E. W. Berry reported to A. C. Tester (1931, p. 265) that the collection from sec. 3, T. 16 S., R. 9 W., southwest of Ellsworth, Kans., contained the following plants:

Andromeda parlatorii Heer
Andromeda pfaffiana Heer
Dammara borealis Heer*
Eucalyptus dakotensis Lesquereux
Liriodendropsis simplex Newberry
?Myrica longa Heer
Myrsine gaudini Lesquereux
Protophyllum sp.
Protophyllocladus subintegrifolius (Lesquereux) Berry
?Rhamnites apiculatus Lesquereux
?Sassafras acutilobum Lesquereux
Widdringtonites reichii (Ettinghausen) Heer*

Only specimens representing the species marked with an asterisk (*) in the foregoing list are now in the collection preserved at the U. S. National Museum. Consequently, I cannot vouch for the validity of the identifications given.

It would appear that Berry did not list the plants from sec. 34, T. 23 S., R. 22 W., south of Hanston, Hodgeman County Kans., in his 1925 report, but in a letter to Dr. Tester, dated July 8, 1930, he mentioned *Dammara borealis* and "probable cycadaceous sporophylls" and requested further material from that locality, which, according to a recent letter, Dr. Tester sent him in April 1931. None of this later material seems to be in the collections. At the moment, therefore, any comments on the fosssil plants from both localities must be restricted to those now at hand and readily recognizable.

Isoetites serratus Brown (1939, p. 268, figs. 1, 2, 4, 5). Figure 5. Only poorly preserved fragments of this quillwort, found originally in the Frontier formation 1 mile east of Cumberland, Wyo., are present, but the serrated apical margin of the leaf, together with the impressions of the collapsed air pockets inside the leaf that simulate spore sacs, renders identification of this fossil easy. This plant is the "probable cycadaceous sporophylls" of Berry's letter. A similar species, somewhat larger, and with little or no apical serration, occurs in the Fort Union formation (Paleocene). For a long time these plants were problematica with many different names and interpretations, but in 1936 I found the clue to their identity and in 1939 published an account of them. The present specimen represents the earliest known American occurrence of the genus. Hodgeman County, Kans.

Dammarites borealis (Heer) Seward, Figures 6–9. These cone scales and seeds represent a coniferous tree that probably resembled the araucarian kauri pine, *Agathis australis* Salisbury, of Australia, in many respects. No foliage, suggestive of *Dammarites*, is present in the collection, but such foliage has been described from the Dakota sandstone under the names of *Dammarites caudatus* Lesquereux and *D. emarginatus* Lesquereux (1891, pl. 1, figs. 9–11). So far as I know, this is the first time the separate winged seeds have been connected with given cone scales. Figure 7 represents the fortunate occurrence of a seed still in place on the left side of the cone scale. Figure 6, Ellsworth County. Figures 7–9, Hodgeman County, Kans.

Dicotyledonous leaf. Figure 4. This may be the leaf Berry identified as probably *Rhamnites apiculatus* Lesquereux (1891, pl. 37, figs. 8–13), but I should want more specimens to be certain of this allocation. Ellsworth County, Kans.

AGE OF THE FOSSILS

In Tester's description of the geologic setting of the Ellsworth County locality (1931, p. 265), the plants are said to have been taken from shales of a "lower zone," the upper surface of which may be channeled locally. Filling these channels, that is, overlying the "lower zone," is coarse-grained, cross-bedded ferruginous sandstone that contains the typical Dakota flora, described by Lesquereux, Heer, and Newberry. Berry's conclusion in regard to the Ellsworth County plants was that "there can be no question but that this horizon in Kansas is Upper Cretaceous" (Tester, 1931, p. 265). In other words, the channeling of the shale containing these plants is inferred not to represent a great lapse of time. I am inclined to agree with Berry on the age of the plants, first, because *Dammarites borealis* has thus far been reported only from known Upper Cretaceous strata. Naturally, it had

ancestors, and perhaps these will some day be reported from Lower Cretaceous rocks. Second, *Isoetites serratus* also has never been reported from the Lower Cretaceous in America, although a somewhat similar species was described by Saporta from the Lower Cretaceous of Portugal.

A review of the sites yielding sharklike egg capsules and plants, such as the Mazon Creek localities of Illinois and the many European localities in Carboniferous, Permian, Triassic, Jurassic, and Lower Cretaceous strata, indicates brackish or near brackish water conditions not far from the sea. The Kansas localities, in Plummer and Romary's terra cotta clay member of the Dakota formation, fit into such a picture, and the strata may represent depositional facies transitional from the marine Kiowa shale or Mentor formation to those commonly but erroneously regarded as the typical Dakota sandstone sequence, which comprises only lenticular, reddish-brown, plant-bearing bodies of harder sandstone that conceal softer, underlying shales.

The problem of drawing a satisfactory map line between the Lower and Upper Cretaceous strata of the Western Interior of the United States remains unsolved. Twenhofel and Tester (1926, p. 561) ventured the opinion that "perhaps it is unwise to attempt such a line." Plummer and Romary (1942, p. 319), on the other hand, in a later review of the situation, restricted the Dakota to "include only the continental and littoral beds that occur above the Kiowa shale and below the Graneros shale," and declared that "the upper and lower boundaries of the Dakota formation are not everywhere sharply defined, but they can be drawn within the limits of a 5- or 6-foot zone." Latta (1946) also discussed this problem, particularly with reference to the Belvidere area in Kansas. Evidently, more field work, with a critical eye for distinctive fossils, will probably have to be done. In the meantime the specimens here described will serve to indicate the possibilities in this direction.

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JOURNAL OF PALEONTOLOGY, VOL. 24, NO. 5, PP. 601–603, 1 TEXT FIG., SEPTEMBER 1950

A NEW SPECIES OF *NIMRAVUS* FROM THE UPPER OLIGOCENE OF SOUTH DAKOTA

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ABSTRACT—A new species of *Nimravus* is described from the upper Oligocene *Protoceras* sandstones of South Dakota. *Nimravus altidens*, n. sp. is the oldest known species of this genus from South Dakota. Its relationship to the other species of *Nimravus* is discussed.

INTRODUCTION

IN STUDYING the phylogeny of the Felidae, the genus *Nimravus* is of particular interest due to its position near the base of the phylum of "True Cats." The species described below may be the oldest known species in the genus. It is older than *Nimravus bumpensis* Scott and Jepsen (1936) as indicated by its occurrence in the *Protoceras* sandstones below the level of the particular zone of the *Leptauchenia* beds where Scott and Jepsen's specimen was found.[1] Its temporal relationship to *N. meridianus* Stock (1933) cannot be absolutely determined until a closer correlation between the faunas from the California Sespe formation and the early Tertiary faunas of the Great Plains has been made. The drawings were made by Mr. Leslie R. Davis.

NIMRAVUS ALTIDENS[2] Macdonald, n. sp.

Type.—Right lower jaw, S.D.S.M.&T. Mus. No. 4053.

Right mandible with portion of C, roots of P_2, unworn P_{3-4} broken M_2, ascending ramus and condyloid process broken away.

Type locality.—*Protoceras* channel sandstone, seven miles east of Rockyford, Shannon County, South Dakota.

Age.—Upper Oligocene, Whitneyan.

Diagnosis.—M_2 slightly elongate, tapered anteriorly; tricuspate. M_1 laterally compressed; oblique; metaconid moderately developed; P_4 laterally compressed; oblique; anterior and posterior accessory cusps subequal. P_3 with anterior accessory cusp; anterior edge of main cusp slightly convex. P_2 double rooted. Exostosis moderately developed below posterior half of M_1, well developed below M_2. Masseteric fossa separated from inferior border of mandible.

Description.—M_2 placed high on mandible with alveolar border opposite crest of metaconid of M_1; tilted anteriorly to 45° angle; tapered anteriorly; three cusps distinguishable. M_2 laterally compressed; slightly tapered anteriorly; metaconid moderately developed; protoconid extends lingually to point opposite posterior end of principal cusp of P_4. P_4 slightly oblique to main axis of mandible; anterior edge extends slightly beyond posterior end of P_3; anterior accessory cusp slightly larger than posterior accessory cusp; principal cusp with anterior and posterior blades similar. P_3 higher than P_4; small anterior cusp; principal cusp with slightly convex anterior blade; posterior blade with slight bulge as in P_4. P_2 small; two rooted; roots only. Canine broken; angle between posterior and lingual face rounded; lingual face rounded. Mandible lightly constructed; exostosis moderately developed below posterior half of M_1, well developed under M_2; coronoid fossa deeply indented under M_2, does not reach inferior border of ramus. Mental foramina below diastema between P_{2-3} and below diastema between P_2 and canine. Antero-inferior corner of ramus slightly crushed with slight actual angulation and no flange,[3] symphysis very short.

Masseteric fossa shows possible incipient breaking through to inferior border of mandible.

[1] James D. Bump, personal communication.

[2] High toothed, referring to the elevated position of M_2.

[3] Crushing gives appearance of moderate development of flange.

Measurements in millimeters

	Nimravus altidens (Type) S.D.S.M.&T. Mus. no. 4053	*Nimravus bumpensis* (Type) S.D.S.M.&T. Mus. no. 348	*Nimravus meridianus*[1] (Type) C.I.T. Mus. no. 462
Length of diastema between C and P_2	11.9	10.8	
P_2, anteroposterior diameter	4.6	4.2	
Length of diastema between P_2 and P_3	2.3	4.8	
Length of diastema between C and P_3	20.1	19.2	15.2
P_3, maximum anteroposterior diameter	13.7	14.1	12.6
P_4, maximum anteroposterior diameter	16.2	15.4	15.2
M_1, maximum anteroposterior diameter	22.3	22.9	21.8
M_2, maximum anteroposterior diameter	5.0	4.6	
Total length, P_3 through M_1	52.5	55.2	46.2

[1] After Stock (1933).

Comparison with other species.—Geologically and geographically, *Nimravus bumpensis* Scott and Jepsen (1936) is the nearest associated species. This species, from the upper portion of the *Leptauchenia* beds, is younger than *Nimravus altidens*. It differs from the new species in having crenulated enamel on the lower cheek teeth. The M_2 is not as elevated and it is rounder and somewhat smaller. The metaconid of M_1 is larger. The P_3 does not have an anterior accessory cusp; and the anterior blade of the principal cusp is concave in contrast to the convex edge in *Nimravus altidens*. The canine has an angular, serrated posterolingual corner and a flattened lingual face. Exostosis is very moderately developed; and the mental foramina are below the posterior root of P_3 and the center of P_2.

Nimravus meridianus Stock (1933) from the Kew Quarry in southern California is also Whitneyan in age. This species more closely resembles *Nimravus altidens* than any of the other known species. The M_2 is nearly as highly elevated. The metaconid of M_1 is somewhat larger but M_1 and P_4 both have a similar oblique orientation with regard to the main axis of the ramus. The two functional premolars are similar in both species although, in the South Dakota form, there is a distinct break in the contour of the posterior blade of principal cusp on P_3. The positions of the mental foramina are different as they are below the posterior root of P_3 and midway between P_3 and the canine. The Californian species also shows less angulation in the symphysial region and less exostosis along the alveolar border of M_1.

Nimravus sectator Matthew (1907) is Arikareean in age as are the remainder of the known species. This species from the lower Rosebud of South Dakota, with the exception of *Nimravus debilis major* (Merriam, 1906) from the middle John Day of Oregon, is the largest species of *Nimravus*. In addition to its large size, it differs from *Nimravus altidens* as it lacks a M_2; M_1 is oriented in line with the main axis of the ramus and the metaconid is relatively large. P_4 is more massive and the diastema between the canine and P_3 is actually as well as relatively shorter. There is no exostosis below M_1.

Three species and a so-called subspecies have been described from the middle John Day beds of Oregon. The genotypic species, *Nimravus gomphodus* Cope (1880) is larger than *Nimravus altidens*, the M_2 is not as highly elevated, the principal cusp of P_4 is not as symmetrical. In addition, P_3 has no anterior accessory cusp and P_2 is absent. There is a slight exostosis below M_1.

Nimravus confertus Cope (1881) is essentially a smaller replica of *N. gomphodus*. It is only two-thirds the size of the larger species. There is no P_2, P_3 is without an anterior accessory cusp, and P_4 has an asymetrical principal cusp. The teeth are aligned with the main axis of the ramus. Exostosis is only moderately developed.

Nimravus debilis (Cope, 1879) and *N. debilis major* (Merriam, 1906) represent a variation in this group which has been re-

garded by some authors as worthy of generic distinction. The masseteric fossa in this species reaches the inferior border of the ramus. In addition to this difference, there is a greater development of the exostosis below the molars, and there is slightly less angulation at the inferior anterior border of the symphysis.

CONCLUSIONS

The exact relationships between the Oligocene members of this genus cannot be determined with the evidence at hand. *Nimravus meridanus* Stock and *N. altidens* are known only from fragmentary mandibles. On the basis of the lower jaws, it appears that these two species, although widely separated geographically, are more closely related to each other than to *Nimravus bumpensis* Scott and Jepsen. If the lack of an anterior accessory cusp on P_3 is an indication of relationship and not a variable within the genus, then *N. altidens*, *M. meridianus* and *N. debilis* show a closer relationship to each other than to the other species. This relationship is further suggested by the indication of an incipient breaking down of the inferior wall of the masseteric fossa in *Nimravus altidens*.

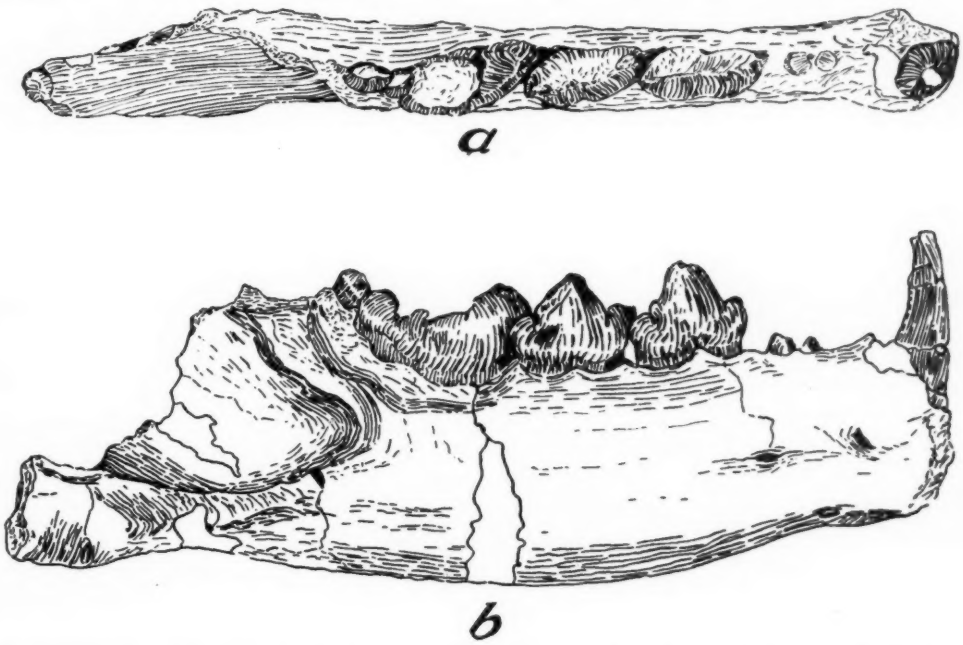

FIG. 1—*Nimravus altidens* Macdonald, n. sp. (Type specimen), right mandible: *a*, occlusal view; *b*, lateral view. No. 4053. ×1.

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A CLASSIFICATION OF THE NAUTILOIDEA

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THERE has been no serious attempt to classify the nautiloid cephalopods since that of Hyatt, in 1900. Since then our genera have been greatly increased, and many were described without much regard to their position in families or higher groups. Meanwhile, investigations have shown that the five major divisions of the nautiloids proposed by Hyatt have serious disadvantages. Only a small part of Hyatt's Holochoanites is actually holochoanitic. In the Cyrtochoanites were grouped forms with siphuncles expanding in the camerae. This sort of structure is now known to develop independently in the Actinoceroidea, in offshoots of the Michelinoceratidae, the Pseudorthoceratidae and Stereoplasmoceratidae, as well as several isolated genera, again in the coiled Rhadinoceratidae, Apsidoceratidae and Uranoceratidae, independent offshoots of the coiled Barrandeoceratidae, while the bulk of the genera constitute the Oncoceratida, which developed cyrtochoanitic structure yet again. The Discosorids constitute a cyrtochoanitic group of uncertain origin. While the Orthochoanites are not convergent morphologically, the group is a large and unwieldy one, and relationships within it have not yet been properly worked out.

The present classification is proposed in order to fill the lack of any recent arrangement sufficiently detailed to indicate orders, families, and the position of at least the commoner and better known genera. In doing this, it has been necessary to erect completely new orders, which have been given endings consistent with those groups which Hyatt apparently intended, though he did not name them, as suborders. Families have had to be considerably revised, and a few new ones erected. A few crucial new generic groups are proposed, though such designations have been kept to a minimum.

[1] Acknowledgment is here made to the U. S. Geological Survey, under the auspices of which background studies for this work have been made.

Hyatt's classification was a definite mark of progress; it involved recognition of the fact that the shape of the shell was not in itself a criterion of relationship, and should not therefore be a deciding factor in classification. However, since Hyatt's day it has become evident that the structure and shape of the segments of the siphuncle are not infallible guides. Indeed, relationships within the group are such that no tenable classification can be erected dividing the nautiloids into a few clearly defined morphological groups capable of a succinct definition.

Some crucial questions relating to the phylogeny of nautiloids should properly be answered before attempting a classification. Though progress has been made, we cannot hope for a final answer on many of these questions for some years yet; in the meantime no usable classification exists. Hence the present proposal, which will serve at least as a better working hypothesis than anything else now available. Space does not permit discussion of some of the fundamental questions, but attention should be called to their existence. First, and perhaps of greatest general interest, did the cephalopods coil independently in several different lines? It is possible, but there does not seem to be good evidence of such a process. On the other hand, the origin of some coiled groups, the Rutoceratida, Solenochilida, and Nautilida, in older coiled groups is a matter not yet adequately established. In earlier coiled forms one encounters the problem of whether the thickened connecting ring of the Tarphyceratida indicates a fundamental difference from the thin homogeneous ring of younger coiled types. In separating orders it has been assumed that such distinctions are significant; yet if so, the origin of most Chazyan or younger stocks of nautilicones is obscure; they are indicated as derived from the Tarphyceratida because no other possibility has yet been found which is at all convincing. True, some coiled genera of the Ordovician cannot be placed in either

group, because they are not well enough known morphologically. The crucial structures can be demonstrated only in exceptionally well preserved materials. A significant clue to relationship may be a feature very difficult to detect in typical fossil material. Should any object to this in principle, it may be stated that quite probably even more significant features would be found in the missing soft parts of the visceral mass.

It is evident that neither the shape of the shell, the form and structure of the siphuncle wall, the presence or absence of actinosiphonate deposits, endocones, concavosiphonate siphuncles, annuli or cameral deposits are in themselves necessarily a reliable guide to major taxonomic categories. Actinosiphonate deposits, taken by Hyatt as a criterion of a major subdivision of his Cyrtochoanites, appear erratically throughout the oncoceroids. They characterize some families, isolated genera, isolated species, and are sometimes known only from one or two gerontic individuals in a species. Nevertheless, it becomes evident that these structures can be explained only as the pattern developed by excess secretion of the connecting ring in the oncoceroids, a stock which had, prior to the development of any such deposit, developed a fundamental pattern of tissues within the siphuncle, which controlled the form of the deposits which developed later. Still other questions involve the position of the Discosorids, concerning the origin of which good evidence is lacking, though the group is a clearly defined one, and useful taxonomically as an order.

No natural classification is properly a linear series. The phylogeny is indicated in the accompanying figure (fig. 1) in which an effort has been made to differentiate probable and doubtful relationships from those which are regarded as well established. Any attempt at a detailed classification to genus soon encounters the problem of the placing of genera of dubious position. Some have been omitted, as placing them anywhere would require a lengthy discussion. Others can be placed in families only tentatively. The doubtful position of such genera has been indicated by a question mark. The omission of many of these forms would leave very large gaps. By indicating their position as clearly open to question, we have avoided the problem which many students face when confronted with a classification in which the well established and highly inferential parts are not distinguished.

Definitions of major groups are admittedly confusing. Relationship is established upon the basis of close similarity, often to the point of intergradation among various of the genera. At an early stage in this investigation a family appeared first to be a small compact group of genera which lent itself readily to a succinct definition. But often further study showed that traceable to this same group were other genera which supplied exceptions to almost every point in the original definition. This is bad in families; it is worse in groups which reach the magnitude of orders; such groups almost defy definition. Probably it is simplest to insist that the whole is the sum of its parts, and that such stocks as the Oncoceratida consist of the compressed exogastric breviconic oncoceroids and all of their descendants, which become slender cyrtocones, straight and endogastric forms, and in the Brevicoceratidae develop into trochoceroids, gyrocones and back to brevicones. Bizarre form changes are no real obstacle to the tracing of relationships, and should not be erected as insuperable barriers between major taxonomic categories. One alternative would be the erection of an artificial classification. We had that fifty years ago, all sixteen genera of it, and it obscured completely the stratigraphic and faunal significance of the natural genetic units, which is becoming increasingly clear as the phylogeny is studied in greater detail. This will be shown in another paper now near completion. Another solution would be the erection of more major taxonomic groups on the basis of such obvious features as form. This was abandoned, since it was felt that the usefulness of the major divisions was greater if their number was kept as small as demonstrable relationships permitted.

For brevity, many problems worthy of more extensive discussion have been bypassed. Among these are various nomenclatorial problems. For the most part, no attempt has been made to settle here questions of synonomy. Questions concerning

relationship are only briefly outlined and indicated in the diagram of the phylogeny. The present summary rests upon much unpublished work which the authors now have in an advanced stage, which will appear elsewhere. The senior author is mainly responsible for the outlining of the orders, and for the pre-Mississippian genera and families. The responsibility for the treatment and disposal of Mississippian forms is divided; the arrangement of the younger genera is largely the responsibility of the junior author. Bibliographic references have been kept at a minimum. Needless to say, other works have been drawn upon extensively. In particular we should cite Teichert (1933) for the actinoceroids, Kobayashi (1935, 1935A,) and Ulrich, Foerste, Miller, etc., 1942–1944) for much data on the older cephalopods, though the classification is mainly an extensive revision of their views (Flower, 1941, 1946, 1947). For data and much of the classification of the late Paleozoic coiled cephalopods acknowledgment should be made to Miller in various publications, particularly Miller and Youngquist (1947), while much of the classification of the Cenozoic Nautilida is that of Spath (1927) and Miller (1947).

The current tendency, indicated in the outlines for the Treatise of Invertebrate Paleontology, is to treat the Cephalopoda as a subphylum of the Mollusca, with three classes, the Nautiloidea, Ammonoidea and Coleoidea. Major divisions of the nautiloids are therefore treated as orders. These names are new, though some groups, as the Actinoceratida, which are essentially the Actinoceroidea of Foerste and Teichert, are new only in the ending used. In other cases, families bear little resemblance to their original definition or contents beside the type genus. These matters it has largely been impossible to indicate in a short work. Finally, it should be emphasized that the present proposals are made more as a report of progress than the presentation of "final" conclusions, depending as they inevitably must upon investigations which are still being continued.

Order ELLESMEROCERATIDA Flower

Shells primitively small, closely septate, siphuncle marginal, relatively large, tubular or concave segments, with extremely short septal necks and connecting rings, when present, relatively thick and often complex in structure. Shells primitively compressed in section, straight or curved with the siphuncle on the concave side. Interior of siphuncle free from endocones, with occasional diaphragms. Included here are the greater number of cephalopods which dominate the lower Canadian or Wanwannian. Other families may depart from the primitive pattern of compressed section and marginal siphuncle, but show their affinities by the thickened connecting ring, vestigial necks, or both.

Family PLECTRONOCERATIDAE Kobayashi (See 1 on fig. 1). Restricted to compressed endogastric cyrtocones with short septal necks. Connecting rings unknown. *Plectronoceras*, Upper Cambrian, China. Possibly some inadequately known genera assigned to the Ellesmeroceratidae, as *Shelbyoceras* may prove to belong here.

Family ELLESMEROCERATIDAE Kobayashi (2). Compressed, closely septate shells, orthocones to endogastric cyrtocones, marginal siphuncles with thick, sometimes complex, connecting rings. Dissepiments may cross the spihuncle. Upper Cambrian: *Shantungendoceras*, (?) *Shelbyoceras*. Lower Canadian: *Dakeoceras*, *Burenoceras*, *Conocerina*, *Clarkeoceras*, *Caseoceras*, *Oneotoceras*, *Buehleroceras*, *Bridgeoceras*, *Levisoceras*, *Quebecoceras*, *Ectenoceras*, *Eremoceras*, *Albertoceras*, *Robsonoceras*, *Stemtonoceras*, *Wanwanoceras*, *Multicameroceras*, *Sinoeremoceras*. Higher Canadian genera are *Cumberloceras*, *Copiceras*, *Clelandoceras*, *Smithvilloceras*.

Family CYCLOSTOMICERATIDAE Ulrich, Foerste, Miller and Furnish (3). Thick-walled marginal siphuncles as in the Ellesmeroceratidae, the shell becoming broader in cross section, shells endogastric to straight or exogastric and breviconic. Canadian. *Cyclostomiceras*, *Woosteroceras*, *Stylocyrtoceras*.

Family PROTOCYCLOCERATIDAE Kobayashi (4). Annulated shells primitively similar to the Ellesmeroceratidae, but becoming broader in cross section and variable but slight curvature. Canadian. *Walcottoceras*, *Protocycloceras*, *Endocycloceras*, *Vassaroceras*, *Rudolfoceras*, *Ectocycloceras*, *Cataraphiceras*.

Family BALTOCERATIDAE Kobayashi (5).

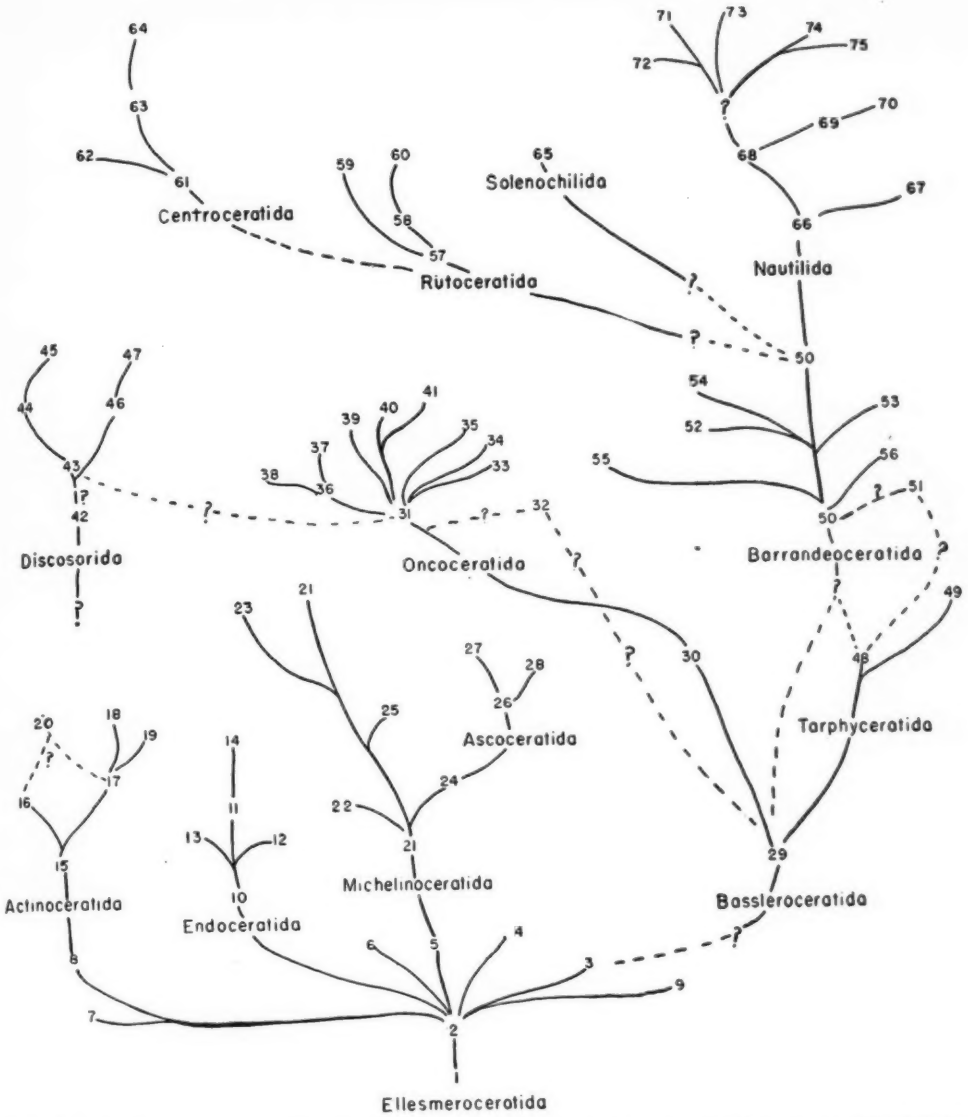

FIG. 1.—Phylogeny of the Nautiloidea. The numbers are those indicating the families in the text. Demonstrable relationships are represented by solid lines. Dubious and alternate relationships are indicated by dotted lines.

1. Plectronoceratidae
2. Ellesmeroceratidae
3. Cyclostomiceratidae
4. Protocycloceratidae
5. Baltoceratidae
6. Buttsoceratidae
7. Cyrtocerinidae
8. Bathmoceratidae
9. Shideleroceratidae
10. Proterocameroceratidae
11. Piloceratidae
12. Manchuroceratidae
13. Chihlioceratidae
14. Endoceratidae
15. Polydesmiidae
16. Actinoceratidae
17. Armenoceratidae
18. Huroniidae
19. Gonioceratidae
20. Sactoceratidae
21. Michelinoceratidae
22. Stereoplasmoceratidae
23. Pseudorthoceratidae
24. Clinoceratidae
25. Paraphragmitidae
26. Hebetoceratidae
27. Choanoceratidae
28. Ascoceratidae
29. Bassleroceratidae
30. Gracilioceratidae
31. Oncoceratidae
32. Allumettoceratidae
33. Hemiphragmoceratidae
34. Trimeroceratidae
35. Brevicoceratidae
36. Valcouroceratidae
37. Jovelaniidae
38. Diestoceratidae
39. Nothoceratidae
40. Acleistoceratidae
41. Archiacoceratidae
42. Ruedemannoceratidae
43. Westonoceratidae
44. Lowoceratidae
45. Discosoridae
46. Cyrtogomphoceratidae
47. Phragmoceratidae
48. Tarphyceratidae
49. Trocholitidae
50. Barrandeoceratidae
51. Plectoceratidae
52. Uranoceratidae
53. Lechritrochoceratidae
54. Rhadinoceratidae
55. Apsidoceratidae
56. Lituitidae
57. Rutoceratidae
58. Tetragonoceratidae
59. Koninckioceratidae
60. Tainoceratidae
61. Centroceratidae
62. Triboloceratidae
63. Domatoceratidae
64. Syringonautilidae
65. Solenocheilidae
66. Liroceratidae
67. Ephippioceratidae
68. Paranautilidae
69. Clydonautilidae
70. Gonionautilidae
71. Nautilidae
72. Paracenoceratidae
73. Cymatoceratidae
74. Herocoglossidae
75. Aturidae

Smooth orthoceracones, similar internally to the Ellesmeroceratidae, developing broader cross section and a siphuncle which may be somewhat separated from the ventral wall. Siphuncle free from deposits, necks vestigial, ring primitively thick, secondarily thin and homogeneous. Ordovician. *Pachendoceras, Baltoceras, Wolungoceras, Oxfordoceras, Ogygoceras, Murrayoceras,* (?) *Eobactrites.*

Family BUTTSOCERATIDAE Flower (6). Orthoceracones differentiated from the Ellesmeroceratidae by a longitudinal central tube within the siphuncle. Upper Canadian. *Buttsoceras.*

Family CYRTOCERINIDAE Flower (7). Endogastric compressed shells, siphuncle submarginal, necks vestigial, connecting ring greatly thickened, projecting into cavity of siphuncle. Middle Canadian: *Eothinoceras.* Middle-Upper Ordovician: *Cyrtocerina. Eothinoceras,* formerly placed in a family by itself, is included, since evidence that this is a straight shell is inconclusive.

Family BATHMOCERATIDAE Holm (8). Shell straight, depressed, siphuncle large, necks relatively long, connecting ring produced into long lobes extending orad into cavity of siphuncle. Lower Ordovician. *Bathmoceras.* Developed from Ellesmeroceratidae, and ancestral to Polydesmiidae of the Actinoceratida.

Family SHIDELEROCERATIDAE Flower (9). Shell cyrtoconic, orientation uncertain, siphuncle central, necks vestigial, rings thin. Upper Ordovician. *Shideleroceras.*

Order ENDOCERATIDA Flower

Shells mainly straight, with large tubular siphuncles containing endocones.

Family PROTEROCAMEROCERATIDAE Flower (10). Shell slender, siphuncle ventral, necks ranging from vestigial to nearly the length of the camera. Siphuncle not enlarged apically. Endocones simple to complex in structure. Siphuncle enclosed in phragmocone to tip of shell. Middle Canadian to Chazyan. *Proterocameroceras* (= *Mcqueenoceras*), *Cotteroceras, Clitendoceras, Cyptendoceras* (= *Kirkoceras*?) (?) *Manitouoceras* (may not be a distinct genus; known from isolated siphuncles), *Paraendoceras, Utoceras, Oderoceras, Oelandoceras, Meniscoceras.* Primitive endoceroids, agreeing with the Ellesmeroceratidae in wall structure of the siphuncle, and set apart from them by the presence of endocones.

Family PILOCERATIDAE Miller (11). Shells rapidly expanding from initial part, siphuncle tending to enlarge very rapidly, mature living chambers may be faintly breviconic; dominantly compressed in section. Septal necks, which tend to elongate in some Proterocameroceratidae, have here attained a holochoanitic condition for the first time. Middle?-Upper Canadian. *Piloceras, Allopiloceras, Cassinoceras.*

Family MANCHUROCERATIDAE Kobayashi (12). Shells grading from slender to rapidly expanding, section generally depressed or circular. Siphuncle wall as in Proterocameroceratidae. Endocones may show elaborate specializations in cross section and in development of blades. *Manchuroceras, Coreanoceras,* and tentatively, *Penhioceras* and *Liaoutungoceras.* Genera of Shimizu and Obata are not placed here or elsewhere, for the descriptions are ambiguous and their morphological conclusions have not been found reliable. One or even several families may be required for some of the Asiatic endoceroids and piloceroids.

Family CHIHLIOCERATIDAE Grabau (13). Canadian. *Chihlioceras* A piloceroid with complex endocones with several concavities.

Family ENDOCERATIDAE Hyatt (14). Orthoconic shells, often very large; septal necks extending apicad at least to next septum, connecting rings usually, probably always retained, passing from the tip of one neck apicad to tip of next. In earlier forms the siphuncle is inflated and may occupy the entire initial part of the shell (*Nanno*), or it may be enclosed in the phragmocone (*Suecoceras*). Again, the swelling may be reduced, and finally lost (*Cameroceras, Foerstellites*). Generic groupings based on early stages have not yet been correlated with those based on mature shells. Chazyan to close of Ordovician. Supposed endoceroids or holochoanitic shells as late as Lower Devonian are reported (*Offleyoceras*) but are inadequately known and relationships are uncertain. *Endoceras, Cameroceras* (probably the apical portion of the same group of species called *Endoceras* when known from adults), *Vaginoceras* with compressed cuneate endosiphotube and vertical blades, dorsal and ventral. *Endoceras* at present has

circular, depressed and triangular cones and blades variously placed, but not vertical. The genus should probably be subdivided on this basis. *Liskeardia* Wilson is doubtfully distinct from *Vaginoceras*. *Cyclendoceras, Cyrtendoceras, Cyrtovaginoceras, Paravaginoceras* and *Nothoceras* Eichwald are undoubted Endoceratidae, the structures not adequately known. *Dideroceras* Flower, n. gen.—Genotype *Endoceras wahlenbergi* Foord, is unique in having septal necks which extend apicad for the length of one and a half to two camerae, with connecting rings. Hyatt attributed this structure to *Vaginoceras*, causing much confusion. Necks in *Endoceras* and *Vaginoceras* extend only for the length of one camera. *Dideroceras* is as yet unknown in North America, but is well developed in Scandinavia and in South America (Cecioni, fide litt. and photographs, 1950). Inadequately known genera include *Colpoceras, Sidemina* and *Conoceras*.

Order ACTINOCERATIDA
(Essentially the Actinoceroidea of Foerste and Teichert)

Shell dominantly straight, siphuncle broadly expanded, usually large, occupied by annular deposits which may fill the entire siphonal cavity except for a vascular system of radial and central canals terminating in a thin cavity against the connecting ring, the perispatium. The classification is essentially that of Teichert (1933) with the removal of a few genera to the Discosoroidea and a few subsequently described forms.

Family POLYDESMIIDAE Kobayashi (15). Siphuncle broadly nummuloidal, annulosiphonate deposits extending inward and orad as in *Bathmoceras*, and are believed to develop from the eyelet, which gives rise to the thick deposits of *Bathmoceras*. Lower Ordovician. Manchuria. *Polydesmia*.

Family ACTINOCERATIDAE Saemann (16). Necks long, recurved, not recumbent; siphuncle large, radial canals arc-like, one series. Ordovician. *Actinoceras, Kochoceras, Saffordoceras, Troostoceras, Polydesmia. Floweroceras* is probably the early stage of some member of this family.

Family ARMENOCERATIDAE Troedsson (17). Siphuncle broadly expanded, brims greater than necks, often recumbent, connecting ring broadly adnate to septum at both ends. Radial canals often complex, of several series, arc-like, becoming transverse later. Ordovician to Lower Devonian. *Nybyoceras, Cyrtonybyoceras, Armenoceras, Elrodoceras, Megadiscosorus, Selkirkoceras, Metarmenoceras*.

Family HURONIIDAE Foerste and Teichert (18). Neck recumbent, brim and neck broadly adnate to part of septum, which is bent apicad and incorporated in siphuncle; apicad end of siphuncle segments often tubular and greatly prolonged. Ordovician-Silurian. *Huronia, Huroniella, Discoactinoceras*.

Family GONIOCERATIDAE Hyatt (19). Siphuncles as in Armenoceratidae. Shell strongly flattened, sides acutely angled in cross section. Ordovician. *Gonioceras, Lambeoceras*.

Family SACTOCERATIDAE Troedsson (20). Siphuncle segments globular or more slender, smaller than in Actinoceroidea. Radial canals leave central canal at right angles. Possibly derived in part from Actinoceratidae and part from Armenoceratidae. Ordovician-Mississippian. *Sactoceras, Ormoceras, Deiroceras, Troedssonoceras, Treptoceras, Paractinoceras, Rayonnoceras, Leurorthoceras*.

Actinoceroids of uncertain position are *Floweroceras* and *Calhounoceras*. *Cyrtactinoceras* is probably not an actinoceroid; its position is uncertain. Not included are numerous generic names proposed by Shimizu and Obata, for which no good use has yet been found by other paleontologists.

Order MICHELINOCERATIDA
Flower

Dominantly orthoceracones, circular in section, siphuncle subcentral, primitively tubular, but secondarily cyrtochoanitic. Necks well developed, rings thin, homogeneous. The origin of the group is probably to be found in the Baltoceratidae. Ordovician-Triassic.

Family MICHELINOCERATIDAE Flower (21). Orthoceracones, with subcentral siphuncles, tubular to very faintly expanded within camerae, necks straight (orthochoanitic) or nearly so (suborthochoanitic). Chazyan through Triassic. Included here are forms previously placed in the ornamented families Kionoceratidae and Cycloceratidae,

since the surface patterns were apparently developed many times independently. Even such generic groups as *Kionoceras* are suspected of containing convergent homeomorphs rather than related elements. Proper classification of the group is delayed, pending closer morphological studies, now in progress. Described genera are *Orthoceros* (probably originally a variation in spelling of *Orthoceras*, but with the designated type, *O. regulare*, this is a valid if small genus) *Michelinoceras* (replacing *Orthoceras* in the broad sense) (=*Trematoceras* Eichwald, =*Arthrophyllum* Beyrich,) *Geisonoceras*, *Geisonocerina*, *Striacoceras*, *Protokionoceras*, *Polygrammoceras*, *Parakionoceras*, *Tretoceras* (?), *Anaspyroceras*, *Metaspyroceras*, *Sactorthoceras*, *Sigmorthoceras*, *Sigmocycloceras*, *Brachycycloceras*, *Hesperoceras* (?), *Ctenoceras* (?), *Centroonoceras*, *Protobaltoceras*, *Bitaunioceras*, *Balticoceras*, *Pseudobactrites* (?), *Arkonoceras*, *Leurocycloceras*, *Harrisoceras*, *Virgoceras*, *Troedssonella*, *Chicagooceras*, *Garryoceras* (?), *Eifeloceras* (?) *Thoracoceras;* also *Cycloceras* and *Spyroceras* in the broad sense. Possibly *Bactrites* is a development from this stock rather than a true ammonoid. Retained in the family are several genera representing individual variations from straight to cyrtoconic shells, also forms exhibiting breviconic living chambers.

Family STEREOPLASMOCERATIDAE Kobayashi (22). Cyrtochoanitic orthoceracones, siphuncle with a continuous lining, nonsegmental, heavy cameral deposits. Segments become broadly expanded at early growth stage, becoming more slender in late maturity. Ordovician. *Stereoplasmoceras*, *Stereoplasmocerina*. *Tofangoceras*, *Tofangocerina;* tentatively placed here are *Eskimoceras*, *Gorbyoceras*, *Striatoceras*, *Ephippiorthoceras*.

Family PSEUDORTHOCERATIDAE Flower and Caster (23). In *Virgoceras* annuli within the siphuncle develop into a continuous lining, each deposit extending orad from its point of origin, joining the next. The Pseudorthoceratidae, developed from this genus, retain such a lining in connection with a cyrtochoanitic siphuncle. Devonian through Permian. *Anastomoceras*, *Diagoceras*, *Dolorthoceras*, *Sceptrites*, *Spyroceras*, (?) *Cyrtospyroceras*, *Cryptorthoceras*, *Fusicoceras*, *Adnatoceras*, *Euloxoceras*, *Mooreoceras*, *Pseudorthoceras*, *Neocycloceras*, *Cayutoceras*, *Bradfordoceras*, *Bergoceras*, *Paraloxoceras*, *Eusthenoceras*, *Pseudocyrtoceras*, *Pseudactinoceras*.

Family CLINOCERATIDAE Flower (24). Shells become fusiform, slightly curved, siphuncle subcentral, planoconvex to biconvex, free from deposits. Derived from Michelinoceratidae through *Centroonoceras; Clinoceras* is apparently the ancestor of the Ascoceratida. Ordovician. *Clinoceras*, *Whitfieldoceras*, (?) *Whiteavesites*.

Family PARAPHRAGMITIDAE Flower, n. fam. (25). Annulated orthoceracones and cyrtocones, aperture tending to be modified, finally becoming breviconic forms with cyrtochoanitic siphuncles. Silurian. *Calocyrtoceras*, *Cyrtocycloceras*, *Gaspocyrtoceras*, *Paraphragmites*.

Order ASCOCERATIDA Flower

Primitively orthoceracones and cyrtocones with a subcentral planoconvex siphuncle, in which natural truncation of the shell appears. Adoral segments of the siphuncle become broadly expanded, the mature part of the shell becomes strongly inflated, the septa rise adorally on the dorsum in this part, finally developing sigmoidal septa. Early stages of such forms are slender cyrtocones with planoconvex segments. Chazyan through Middle Silurian.

Family HEBETOCERATIDAE Flower (26). Shells slender or inflated adorally, adoral sutures swing forward on dorsum in advanced forms, but sutures are not sigmoid. *Montyoceras*, *Hebetoceras*, *Ecdyceras*, *Pachecdyceras*, *Probillingsites*, *Shamattawaceras*. Ordovician.

Family CHOANOCERATIDAE Miller (27). Shells slender, slightly curved, septa strongly conical, fused adorally ventrad of siphuncle. Ordovician-Silurian. *Choanoceras*.

Family ASCOCERATIDAE Barrande (28). Mature shell inflated, aperture produced, retaining at most one normal septum and several ascoceroid septa with sigmoid sutures. Upper Ordovician-Silurian. *Schuchertoceras*, *Billingsites*, *Lindstromoceras*, *Parascoceras*, *Pseudascoceras*, *Ascoceras*, *Aphragmites*, *Glossoceras*.

Order BASSLEROCERATIDA Flower

Exogastric cyrtocones, compressed, ventral tubular siphuncle.

Family BASSLEROCERATIDAE Ulrich, Foerste, Miller and Unklesbay (29). Closely septate, siphuncle with thickened connecting ring; generally compressed forms with strongly developed lateral lobes. Canadian. *Basslerocerας, Avaoceras, Diaphoroceras, Dwightoceras, Dyscritoceras, Lawrensoceras, Leptocyrtoceras, Monogonoceras,* Probably developed from Cyclostomiceratidae.

Family GRACILOCERATIDAE Flower, n. fam. (30) Exogastric cyrtocones, probably derived from the Basslerocerατidae, from which they differ mainly in the thin homogeneous connecting ring. Ordovician. *Graciloceras, Eorizoceras, Piersaloceras,* (?) *Ringoceras.* Strangely, the persistance of this generalized stock rests upon few forms in the Ordovician, and none have as yet been recognized in younger beds. The family is the origin of the cyrtochoanitic Oncoceratida on one hand, while the Basslerocerατidae gave rise to the Tarphyceratida. The Basslerocerατida is unquestionably the beginning of a long-lived stock of nautiloids with a persistently ventral siphuncle. The derivation of most nautiliconic lines in this stock seems an inevitable conclusion, for true transitions from the Michelinoceratidae have not been demonstrated. The exact point of origin of younger coiled stocks is yet uncertain. It has seemed best to treat them as constituting several independent orders.

Order ONCOCERATIDA Flower

Exogastric cyrtocones, primitively compressed, often with aperture considerably contracted, siphuncle ventral, suborthochoanitic in young, cyrtochoanitic in adult, but often with relatively slender segments. Actinosiphonate deposits appear in various members of the group. Some shells become secondarily straight and endogastric. Embraces the greater number of cyrtocones and brevicones of the Paleozoic, and includes some coiled derivatives.

Family ONCOCERATIDAE Hyatt (31). Compressed brevicones and cyrtocones, including secondarily forms of broader section, siphuncle ventral, generally free from deposits, relatively slender in older forms. This stock includes the greater number of Ordovician cyrtocones, apparently persisting as *Oonoceras* into the Silurian, giving rise to a second great expansion including straight and endogastric forms. Apparently many Ordovician and Silurian genera are distinct though strongly homeomorphic. The history of the group in the Devonian is yet uncertain. Ordovician: *Oncoceras, Nelimenia, Maelonoceras, Beloitoceras, Cyrtorizoceras, Rizoceras, Oonoceras, Richardsonoceras, Dunleithoceras, Laphamoceras, Zitteloceras, Loganoceras, Kentlandoceras, Schofieldoceras, Miamoceras, Ehlersoceras, Romingeroceras, Neumatoceras, Vaupellia.* Silurian: *Oonoceras, Rizoceras, "Cyrtorizoceras"* (homeomorphs), *Oocerina, Blakeoceras, Perimecoceras, Danaoceras, Metarizoceras* (=*Euryrizoceras, Cyclorizoceras*), *Ectocyrtoceras, Coelocyrtoceras, Ekwanoceras, Crateroceras, Amphicyrtoceras, Worthenoceras, Clionyssiceras, Byronoceras, Gonatocyrtoceras, Austinoceras, Anomeioceras, Rhomboceras Galtoceras, Grimsbyoceras, Perioidanoceras, Slocomoceras.* Devonian: *Karoceras,* and doubtfully *Cyrtogomphus, Tumidoceras, Sycoceras, Mecynoceras, Pachtoceras, Hipparionoceras.*

Family ALLUMETTOCERATIDAE Flower (32). Shells straight or faintly exogastric, venter flattened, section depressed, siphuncle ventral, cyrtochoanitic or suborthochoanitic. Ordovician: *Allumettoceras, Tripteroceras, Tripterocerina, Rasmussenoceras, Hadeoceras,* Devonian: (?)*Tripleuroceras,* (?)*Eudoceras.* Tentatively included in onconceroids; origin actually quite dubious. Devonian forms may be homeomorphic, but no other origin as yet suggests itself for these forms.

Family HEMIPHRAGMOCERATIDAE Foerste (33). Endogastric brevicones essentially straight adorally, siphuncle nummuloidal, actinosiphonate, aperture with hyponomic sinus and paired lateral sinuses. Silurian. *Mandaloceras, Tetrameroceras, Hemiphragmoceras, Octameroceras, Conradoceras, Hexameroceras.*

Family TRIMEROCERATIDAE Hyatt (34). Superficially similar to the above, but exogastric, siphuncle slender, with no deposits, usually with a median dorsal sinus. Silurian. *Trimeroceras, Pentameroceras, Inversoceras, Clathroceras, Ovocerina,* doubtfully *Gomphoceras, Phragmocerina.*

Family BREVICOCERATIDAE Flower (35). Exogastric trochoceroids, gyrocones and brevicones stemming from *Oonoceras* in the Silurian, tending to develop vestigial actinosiphonate deposits and a subtraingular sec-

tion. Silurian: *Oxygonioceras, Mitroceras, Foersteoceras* Devonian: *Naedyceras, Gonionaedyceras, Gyronaedyceras, Stereotoceras, Brevicoceras, Arctinoceras, Wissenbachia, Exocyrtoceras, Verticoceras, Ovoceras, Eleusoceras, Micronoceras, Blastocerina, Aletoceras, Anglicornus.*

Family VALCOUROCERATIDAE Flower. (36). Exogastric cyrtocones and brevicones with ventral actinosiphonate siphuncles, section broadening with flattened dorsum, becoming subtriangular to broadly depressed. Ordovician: *Minganoceras, Valcouroceras, Augustoceras, Staufferoceras, Fayettoceras;* Ordovician-Silurian: *Manitoulinoceras, Kindleoceras.* Doubtfully, *Actinomorpha* (Ord.)

Family JOVELLANIIDAE Foord (37). Shells derived from Valcouroceratidae: actinosiphonate, developing into orthoceracones and cyrtocones of triangular to depressed section. Sil.—Devonian. *Mixosiphonoceras, Jovellania, Projovellania* (?), *Herkimeroceras.*

Family DIESTOCERATIDAE Foerste (38). Straight to faintly endogastric brevicones, compressed, marginal actinosiphonate siphuncles. Ordovician. *Danoceras, Diestoceras, Pictetoceras*(?).

Family NOTHOCERATIDAE Teichert (39). Breviconic to nautiliconic shells, aperture faintly contracted, siphuncle ventral, generally concavosiphonate, actinosiphonate. Section depressed. Devonian. *Turnoceras, Conostichoceras, Nothoceras, Cranoceras* (= *Cyrtoceratites, Cyrtoceras,* of authors), *Lorieroceras* (?).

Family ACLEISTOCERATIDAE Flower, n. fam. (40). Depressed exogastric brevicones, siphuncle broadly expanded, often actinosiphonate. Devonian. *Acleistoceras, Ptenacleistoceras, Poteriocerina, Paracleistoceras.* Possibly *Poterioceras* (Miss.). Derived from *Amphicyrtoceras* of the Silurian Oncoceratidae, which with its allies may eventually be removed to this family; they apparently spring from Ordovician *Oncoceras* independent of the *Oonoceras* line.

Family ARCHIACOCERATIDAE Teichert (41). Exogastric shells with a broadly expanded actinosiphonate dorsal siphuncle. Devonian: *Archiacoceras,* possibly *Wadeoceras.*

A large number of breviconic genera are not included. The proposal of generic names has far outstripped adequate knowledge of morphology, the prerequisite for any conclusions concerning relationship and classification. Most brevicones of the Paleozoic seem to belong to the Oncoceratida, and the need of a separate group has not become apparent. Some genera have, however, been traced to the Discosorida. Adequate criteria for placing Devonian forms of phragmoceroid aspect and concavosiphonate siphuncles are yet lacking (*Bolloceras, Metaphragmoceras, Paraconradoceras*).

Order DISCOSOROIDEA Flower

Cyrtochoanitic cyrtoceracones, the siphuncles broadly expanded from an early stage, in contrast to the oncoceroids which are primitively suborthochoanitic in the early stages. The connecting ring thickens early in the group, to which are added annulosiphonate deposits and at length, endocones. Specialized forms retain endocones, but may lose the annulosiphonate deposits and the thickening of the rings. The origin of the group is uncertain. Wide structural differences separate the Ruedemannoceratidae from the Actinoceroidea, but no other possible ancestors are known. If the Ruedemannoceratidae are distinct from other discosorids, it may be possible to trace the main part of the group from the Westonoceratidae back to the oncoceroids.

Family RUEDEMANNOCERATIDAE Flower (42). Cyrtocones with broadly expanded subcentral siphuncle, rings thickened, no other siphonal deposits; heavy cameral deposits. Ordovician. *Ruedemannoceras, Yabeites.*

Family WESTONOCERATIDAE Foerste and Teichert (43). Exogastric to straight shells, siphuncle ventral, at least in early stages, rings thickened, annuli and sometimes endocones developed in siphuncle. Ordovician. *Westonoceras, Teichertoceras, Kiaeroceras, Faberoceras, Reedsoceras*(?), *Winnipegoceras*(?), *Clarkesvillea, Glyptodendron.*

Family LOWOCERATIDAE Flower (44). Cyrtocones with relatively slender nummuloidal siphuncles, not rapidly expanding orad in shell, siphuncles with endocones; annuli lost, thickening of ring slight or wanting. Silurian: *Lowoceras, Tuyloceras.*

Family DISCOSORIDAE Teichert (45). Siphuncle of broadly expanded segments,

enlarging rapidly as traced orad in phragmocone; shells generally breviconic. Silurian-Devonian. *Discosorus, Endodiscosorus, Stokesoceras, Kayoceras, Alpenoceras.* Schindewolf's (1942) revision redefines *Discosorus* in such terms that it is dubious whether the genotype would be included.

Family CYRTOGOMPHOCERATIDAE Flower (46). Forms similar to the Westonoceratidae, but dominantly with the siphuncle on the concave side of the shell. Ordovician. *Cyrtogomphoceras, Landeroceras, Strandoceras, Lyckholmoceras* (?).

Family PHRAGMOCERATIDAE Hyatt (47). Endogastric compressed shells, siphuncle close to concave side, thickening of rings often reduced, annuli wanting. Connected to Cyrtogomphoceratidae by close relationship of *Protophragmoceras* and *Strandoceras*. Silurian. *Protophragmoceras, Endoplectoceras, Phragmoceras, Tubiferoceras.*

Order TARPHYCERATIDA Flower

Coiled cephalopods, having persistently a thick complex connecting ring as in the Basslerocerati dae and Ellesmerocerati da, Siphuncle ventral in young, may become central or dorsal in adult.

Family TARPHYCERATIDAE Hyatt (48). Shell gyroconic or tightly coiled, siphuncle ventral or central, but ventral in young. Canadian. *Aphetoceras, Clytoceras, Pycnoceras, Shumardoceras, Cycloplectoceras, Alaskoceras, Campbelloceras, Centrotarphyceras, Eurystomites, Pionoceras, Pilotoceras, Seelyoceras* (?).

Family TROCHOLITIDAE Chapman (49). Siphuncle in adult dorsad of center, may be ventral in young or central as in more advanced types. Canadian: *Arkoceras, Curtoceras, Jasperoceras, Litoceras, Trocholitoceras, Wichitoceras.* Ordovician: *Trocholites, Discoceras* (=*Schroederoceras*) Silurian: *Graftonoceras.*

Order BARRANDEOCERATIDA Flower

Nautilicones with the siphuncle primitively tubular, connecting rings thin, homogeneous, siphuncle central or ventral. Strong similarity of form suggests an origin in the Tarphyceratidae, but differences of internal structure suggest the possibility of the development of these forms from the Gracilocerati dae or from some as yet unrecognized Canadian stock. Until the question can be decided, the use of a separate order for these forms seems desirable, and the name Barrandeoceratida is selected in order to base the group upon an old and a well known genus. *Deltoceras*, the type of the family Deltoceratidae, has never been figured and there is some question as to its identity and relationship. The disposal of some Ordovician genera in the Tarphyceratida and Barrandeoceratida, is impossible their siphuncles not being adequately known.

Family BARRANDEOCERATIDAE Foerste (50). Coiled nautiloids, dominantly compressed, siphuncle subcentral, secondarily ventral. Ordovician: *Barrandeoceras, Deltoceras*(?), *Centrocyrtoceras, Paquettoceras.* Ord.-Sil.: *Bickmorites,* (=*Tyrrelloceras, Leuronotoceras, Goniotrochoceras*). Sil.: *Gasconsoceras, Laureloceras.* Dev.: *Haydenoceras.* Doubtfully, *Savageoceras* (Sil.)

Family PLECTOCERATIDAE Hyatt (51). Costate shells, the siphuncle close to the venter in the adult. Ordovician *Plectoceras* (=*Metaplectoceras*). May be derived independently from *Cycloplectoceras* of the Tarphyceratidae, but internal structure suggests relationships with the Barrandeoceratidae instead.

Family URANOCERATIDAE Hyatt (52). Gerontically uncoiled forms derived from *Bickmorites*, the siphuncle tending to expand in the camerae, the surface becoming simple. Silurian. *Jolietoceras, Uranoceras, Cumingsoceras* Flower, n. gen., genotype *Gigantoceras elrodi* (White). A compressed rapidly expanding coiled shell, whorls narrowly separated, siphuncle subcentral, necks recumbent. Differs from *Heracloceras* with which it is homeomorphic in the lateral lobes of the sutures.

Family LECHRITROCHOCERATIDAE Flower, n. fam. (53). Dextral costate trochoceroids, derived from *Bickmorites*. Silurian. *Lechritrochoceras, Leurotrochoceras, Peismoceras, Systrophoceras, Catyrephoceras, Trochodictyoceras.*

Family RHADINOCERATIDAE Hyatt (54). Derived from *Bickmorites;* trochoceroids, gyrocones, nautilicones and breviconi. Siphuncle becomes central and broadly expanded. Devonian. *Sphyradoceras. Baeo-*

pleuroceras, Lyrioceras, Nephriticerina, Endoplanoceras, Heracloceras, Nephriticeras, Rhadinoceras, Hipparionoceras?

Family APSIDOCERATIDAE Hyatt (55). Coiled shells, developing a broad flat venter, lateral lobes, a subcentral cyrtochoanitic siphuncle. Evidently an Ordovician group derived from the Bickmoritidae. Ordovician. *Apsidoceras, Deckeroceras, Fremontoceras, Charactoceras, Charactocerina, Wilsonoceras.*

Family LITUITIDAE Noetling (56). Coiled shells, secondarily becoming straight, siphuncle subcentral, tubular, growth lines with ventral and a pair of lateral sinuses. Ordovician. *Lituites, Cyclolituites, Angelinoceras, Tyrioceras, Holmiceras, Ancistroceras, Rhynchorthoceras.* I tentatively place here the Silurian *Ophidioceras*, since no other origin for the genus seems likely.

Ordovician nautilicones of uncertain position are *Planctoceras, Falcilituites, Estonioceras* and *Remeleceras.*

Order RUTOCERATIDA Flower

Loosely coiled shells, section depressed, sutures primitively simple, surface showing varices of growth expressed as wings, spines, ribs, nodes, or frills; later developing into more closely coiled forms in which the varices are partially or completely suppressed, the whorl section becomes angular, subquadratic, lenticular or ovoid, some shells becoming essentially smooth. Siphuncle primitively ventral, may migrate to a central or even a dorsal position in younger forms. Here are joined the Rutoceratida and Hercoceratida of Hyatt, because no good distinction could be found between the groups, on the basis of Devonian representatives.

Family RUTOCERATIDAE Hyatt. This family, now in process of monographic treatment (Flower, ms.) consists dominantly of gyrocones of depressed section, whorl generally rounded, siphuncle ventral, tubular or faintly expanded, surface with varices of growth variously expressed as wings, frills, spines, nodes, the surface often with longitudinal lirae. Devonian: *Ptenoceras, Trochoceras, Ptyssoceras, Pleuroncoceras* Flower, n. gen., genotype: *Spirula nodosa* Bronn, 1837. [Gyroconic, shell thin, with only faint growth lines and longitudinal lirae, sides of shell expanded into a pair of hollow nodose lateral expansions of the shell. Intermediate between *Ptenoceras* and *Hindeoceras*, also the probable ancestor of *Temnocheilus* and *Endolobus.*] *Hindeoceras, Casteroceras, Kophinoceras, Diademoceras, Threaroceras, Tetranodoceras, Halloceras, Goldringia, Centrolitoceras, Rutoceras, Adelphoceras, Homoadelphoceras, Hercoceras, Anomaloceras, Paleogoniatites* (?).

Family TETRAGONOCERATIDAE Flower (58). Gyroconic to tarphyconic shells, developed from *Hercoceras*, with tetragonal section, narrower at umbilical than at abdominal angles, primitively with two pairs of lateral nodes which may be lost later. *Nassauoceras, Wellsoceras, Tetragonoceras.*

Family KONINCKIOCERATIDAE Hyatt (59). Evolute nautiloids of depressed section, large umbilicus, simple sutures, subcentral siphuncle. (Miss.-Perm.); *Endolobus, Edaphoceras, Koninckioceras.* (Miss.-Penn.); *Planetoceras.* (Penn.-Perm.) *Knightoceras.*

Family TAINOCERATIDAE (60). More closely coiled shells, ornamented with one to several pairs of nodes or spines and ribs, whorl subtrigonal to subquadratic. *Temnocheilus* (Miss.-Perm.) *Foordiceras* (Perm.) *Metacoceras* (Penn.-Perm.), *Mojsvaroceras* (Trias.), *Parametacoceras* (Penn.), *Tainoceras* (Penn.-Perm., Trias,?), *Cooperoceras* (Perm.), *Tainionautilus* (Perm.-Trias.), *Tirolonautilus* (Perm.), *Aulametacoceras* (Perm.-Trias.), *Germanonautilus, Thuringionautilus, Pleuronautilus* (Subgenera: *Enoploceras, Holconautilus, Anoploceras, Encoiloceras, Trachynautilus*), *Phloioceras* (Trias.).

Order CENTROCERATIDA Flower

Gyroconic to nautiliconic, whorl primitively quadrate, venter narrow, dorsum broad; section may develop a concave venter, and may then become broad and rounded, strongly lirate surface developing. The origin of the Centroceratidae is uncertain, but possibly in the Tetragonoceratidae; the relationship of the Domatoceratidae is obvious. The tracing of the Triboloceratidae to this group is based upon a premise, but no other close relationship exists between members of the group and other possible ancestral stocks.

Family CENTROCERATIDAE Hyatt (61). Whorl strongly quadrate, dorsum broad, venter narrow, section compressed, at least ventral angles well defined; younger forms may have an impressed zone. Devonian:

Centroceras, Strophiceras, Homaloceras, Carloceras. Mississippian: *Diorugoceras, Phaceras.*

Family TRIBOLOCERATIDAE Hyatt (62). Here are united the Triboloceratidae, Trigonoceratidae and Rineceratidae of Hyatt. Regarded as derived through the compressed smooth *Mesochasmoceras* and *Apheleceras*, from the Centroceratidae, leading to lirate forms of rounded or broad whorl on one hand, including *Discitoceras, Stroboceras, Rineceras, Lispoceras, Thrincoceras, Trigonoceras*, to forms with a concave abdomen, *Triboloceras, Vestinautilus, Coelonautilus, Trigonoceras*, broad smooth—whorled forms, *Diodoceras*, (?)*Planetoceras*, and (from *Mesochasmoceras*), *Maccoyoceras, Leuroceras.* Mississippian.

Family DOMATOCERATIDAE Miller and Youngquist (63). Evolute to involute, generally compressed conchs, unornamented, sutures with broad lateral lobes, tending toward modification of ventral suture. *Domatoceras* (Penn.-Perm.), *Grypoceras, Menuihionautilus* (Trias.); *Stenopoceras, Stearoceras* (Penn.-Perm.); *Pselioceras* (Perm.), *Titanoceras* (Miss.-Penn.).

Family SYRINGONAUTILIDAE Mojsisovics (64). Evolute to involute, rounded to compressed, smooth shells, showing in some genera modification of the suture; probably derived from the Domatoceratidae. Triassic. *Syringonautilus, Syringoceras, Juvavionautilus, Oxynautilus, Clymenonautilus.*

Order SOLENOCHILIDA Flower

Shells smooth, rapidly expanding, loosely coiled to involute; sutures simple, siphuncle ventral. A small late Paleozoic group, of uncertain origin.

Family SOLENOCHILIDAE Hyatt (65). Characters of order. *Solenochilus, Oncodoceras, Asymptoceras, Aipoceras*, (?)*Acanthonautilus.* Mississippian *Solenochilus* persists to the Permian. The siphuncle of *Acanthonautilus* is unknown and its position therefore unproved. Miller has regarded *Permonautilus* as a synonym. Its siphuncle is central and it belongs plainly to the Liroceratidae.

Order NAUTILIDA Spath

Conch involute, generally smooth, sinuous plications developed in some groups, depressed to compressed, siphuncle central or dorsal, suture straight to strongly sinuous.

Family LIROCERATIDAE Miller and Youngquist (66). Smooth, involute globose conchs, very simple sutures and central siphuncles. *Liroceras* (Miss.-Perm.), *Coelogasteroceras* (Penn.-Perm.), *Peripetoceras* (Miss.-Perm.), *Condraoceras* (Penn.), *Permonautilus* (Perm.)

Family EPHIPPIOCERATIDAE Miller and Youngquist (67). Involute generally smooth conch, whorl rounded, sutures with deep ventral and dorsal saddles; probably derived from Liroceratidae. *Ephippioceras* (Miss.-Perm.), *Megaglossoceras* (Penn.).

Family PARANAUTILIDAE Kummel (nov.) (68). Involute, globular smooth conchs, with simple almost straight sutures; probably derived from Liroceratidae. Triassic. *Paranautilus, Indonautilus, Sibyllonautilus.*

Family CLYDONAUTILIDAE Hyatt (69). Involute, generally smooth conchs, with some ornamented forms. Sutures very sinuous, forming distinct lobes, probably derived from the Paranautilidae. Triassic. *Styrionautilus, Proclydonautilus, Cosmonautilus, Callaionautilus, Clydonautilus.*

Family GONIONAUTILIDAE Kummel (nov.) (70). Involute, smooth, compressed conch, highly sinuous suture with double annular lobe; probably derived from Clydonautilidae. Triassic. *Gonionautilus.*

Family NAUTILIDAE d'Orbigny (71). Involute or slightly evolute, generally smooth, compressed to depressed conchs, sutures straight to sinuous. *Nautilus* (Eocene-Recent), *Bisiphytes* (?) (Juras.), *Cenoceras* (Juras.), *Eutrephoceras* (Juras.-Oligo.), *Sphaeronautilus, Digonioceras, Ophionautilus* (Juras.), *Angulithes* (Cret.), *Pseudocenoceras* (Cret.)

Family PARACENOCERATIDAE Spath (72). Nautiliconic conchs, with sinuosity of suture line and characterized by differentiation of the periphery of the shell. *Paracenoceras, Tithonoceras, Somalinautilus, Aulaconautilus*, (Juras.), *Heminautilus, Carinonautilus* (Cret.).

Family CYMATOCERATIDAE Spath (73). Nautiliconic conchs with sinuous transverse ribs, suture may be quite sinuous. *Cymatoceras* (Cret.), *Procymatoceras, Cymatonautilus*, (Juras.); *Paracymatoceras* (Juras.-Cret.), *Syrionautilus, Anglonautilus, Eucymatoceras*, (Cret.).

Family HERCOGLOSSIDAE Spath (74). Nautiliconic conchs with "goniatitic" suture lines. *Pseudaganides, Hercoglossoceras, Pseudonautilus* (Juras.); *Hercoglossa* (Juras.-Eocene); *Aturoidea* (U. Cret.-Eocene), *Deltoidonoutilus* (Eocene), *Cimomia* (U. Cret.-Oligo.), *Woodringia* (Paleocene).

Family ATURIDAE Hyatt (75). Nautiliconic compressed conch, advanced suture, a dorsal marginal siphuncle with elongated septal necks. *Aturia* (Paleocene-Miocene).

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PALEONTOLOGICAL NOTES

AN ONONDAGAN FAUNULE IN NEW JERSEY

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ABSTRACT—Few fossils have been found in the early Middle Devonian Esopus formation in New Jersey. Ten additional species are reported from the formation, and evidence is presented which indicates the Esopus to be of Onondagan age.

INTRODUCTION

The Esopus formation is one of the most prominent and persistent units of the early Middle Devonian section in northwestern New Jersey. The formation can be traced for some 30 miles across the northwestern part of the state from the Wallpack Bend of Delaware River, northeast to the state line near Port Jervis, New York; and it continues for many miles in a northeasterly direction, well into New York. It can also be traced southwest into Pennsylvania, to an area a few miles southwest of Stroudsburg where its position in the stratigraphic section is occupied by the Bowmanstown chert and the Palmerton sandstone (Swartz and Swartz, 1941).

Throughout New Jersey, the Esopus formation is chiefly a dense, dark-gray, fine-grained, argillaceous siltstone, but it frequently contains calcareous and sandy beds, especially in its upper portion. The formation is further characterized by an intense development of cleavage which often obscures the bedding. This feature is generally more pronounced in the lower portion of the formation, perhaps because of the more shaly habit of that part of the rock. The bedding surfaces frequently show the markings of the supposed fucoid *Taonurus caudagalli* (Vanuxem), and this aids in distinguishing the bedding from the cleavage. The Esopus formation is underlain with apparent conformity by the Oriskany formation, and grades upward into the Onondaga limestone (Buttermilk Falls limestone of Willard, 1936).

The formation appears to be of rather uniform thickness between Stroudsburg and Wallpack Centre, but thickens toward the northeast. At Experiment Mills, near Stroudsburg, Pennsylvania, it is 275 feet thick (Swartz and Swartz, 1941), and at Wallpack Centre, New Jersey, Mr. R. E. Stevenson and I obtained a measurement of 272 feet. Farther northeast, near Montague, New Jersey, we measured at least 310 feet of Esopus beds without reaching the top of the formation. In the vicinity of Port Jervis, New York, the Maximum thickness of the Esopus formation was reported as approximately 550 feet (Shimer, 1905), and Stuart Weller gave the average thickness in New Jersey as 375 feet (Weller, 1903).

The attitude of the formation is, in general, that of a monoclinal bed, striking in a northeasterly direction and dipping northwest at an average angle of approximately 30 degrees. Locally, well-developed folding has been seen. Because of its resistant character, the formation supports a prominent ridge, known in New Jersey as the Wallpack Ridge.

PALEONTOLOGY

The Esopus formation contains relatively few fossils, except for the above-mentioned *Taonurus caudagalli* (Vanuxem), and the lower portions are particularly poor in fossils. Such fossils as have been found have usually been greatly distorted by the folding, and because of the intense cleavage, they are difficult to collect, prepare and identify. In 1903, Weller reported that, aside from *Taonurus caudagalli* (Vanuxem), "a single, imperfect specimen of an inarticulate brachiopod, probably *Lingula* or *Orbiculoidea*,

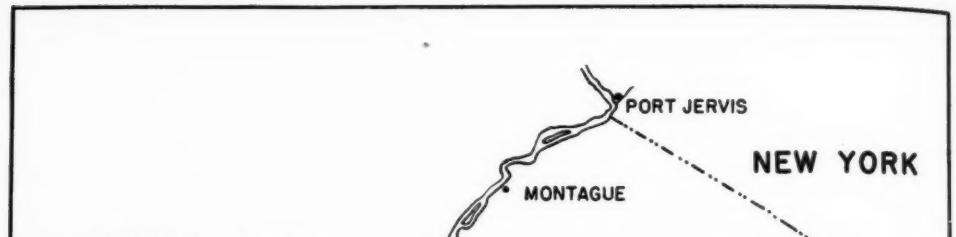

FIG. *1*—Sketch map of northern New Jersey and adjacent area, showing geographical positions of locations mentioned in this article.

has been found in an outcrop of this formation near Flatbrookville, but no other specimens have been observed." More recently, the brachiopod species *Leptocoelia flabellites* (Conrad) and *L.* (*Anoplotheca*) *acutiplicata* (Conrad) have been observed at several exposures of the Esopus formation in New Jersey by Meredith E. Johnson, State Geologist, and me.

In the spring of 1948, I had the good fortune to come upon a highly fossiliferous exposure of the Esopus formation in a road cut near Montague, New Jersey. The beds exposed were found to be approximately 200 feet above the base of the formation. The rock is a series of grey, thin-bedded, fine-grained calcareous sandstones, weathering to a buff color, which grade downward into a grey, fine-grained calcareous shale. The beds are overlain by dark-grey, fine-grained, calcareous, argillaceous sandstone which contains only *Taonurus caudagalli* (Vanuxem). The exposure has been revisited, and the following fossils have been identified from the material collected:

Zaphrentis sp.
**Conularia gaspesia* Sinclair
**C. sussexensis* Herpers
*Crinoid columnals
Leptocoelia flabellites (Conrad)
L. (*Anoplotheca*) *acutiplicata* (Conrad)
**Anoplotheca dichotoma* (Hall)
**"Spirifer" varicosus* Hall
**Rhipidomella vanuxemi* Hall
**Platyceras* cf. *dumosum* (Conrad)
**P. undatum* Hall
*Ostracoda spp.
*Fucoid? (a stem)
Taonurus caudagalli (Vanuxem)

Excluding the *Taonurus caudagalli* (Vanuxem), the most abundant species in the faunule are *Leptocoelia flabellites* (Conrad), *L.* (*Anoplotheca*) *acutiplicata* (Conrad) and the two species of *Conularia*. The species marked with an asterisk are, so far as I know, reported from the Esopus formation for the first time.

SIGNIFICANCE

The faunule is of significance for two reasons. First, it represents a substantial addition to the numerically small (22 species) known fauna of the Esopus formation as a whole (Willard, 1939; Goldring, 1943; Howell, 1942). Second, and probably of greater importance, is the Onondagan affinity of the faunule, *Anoplotheca dichotoma* (Hall), *"Spirifer" varicosus* Hall, *Rhipidomella vanuxemi* Hall and *Platyceras* cf. *dumosum* (Conrad) being particularly indicative of formations of Onondaga age. This gives additional paleontological support to the idea advanced by Willard that "the Onondaga group in Pennsylvania is defined to include all stratigraphic units between the top of the preceding Oriskany group and the succeeding Marcellus formation of the Hamilton group" (Willard, 1939). In a previous work, Willard included the Onondaga limestone in Pennsylvania as a member of his new Onondaga group, and redesignated the limestone as Buttermilk Falls limestone (Willard, 1936). The Esopus formation in New Jersey may therefore represent a shaly facies, and the Onondaga limestone (Buttermilk Falls limestone of Willard), a calcareous facies of the Onondaga group, as defined above.

ACKNOWLEDGEMENTS

This work was done while I was on leave from the New Jersey Geologic and Topographic Survey, and was engaged in graduate study in the Department of Geology at Lehigh University. I am indebted to Dr. Bradford Willard of Lehigh University for his assistance and encouragement, and to Mr. Meredith E. Johnson, State Geologist of New Jersey who also gave encouragement and valuable criticism.

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A PALEOBOTANICAL TRANSFER METHOD

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The study of carbonized compression flora has long been handicapped by the lack of an effective method of rapid determination of preserved structural details. The Walton method of securing films of compressions is not only complicated and tedious but also expensive in time and materials. The standard Schultz maceration process, when used to reduce carbonaceous shale or coal, destroys or dissociates most plant material except spores.

Peels or transfers of coal balls and silicified wood have been made with notable success by several methods. However, no very successful method of stripping entire carbonized compressions from shale or clay has been reported previously. The following method has been developed whereby not only gross outline of carbonized foliage and venation, but also cellular structure of epidermis and sub-epidermal regions have been removed from their rock matrix without fragmentation or serious loss of carbonized film.

SCHEDULE FOR ACID-SOLUBLE SHALE

1. Dry fossiliferous rock for 24–48 hours in usual manner. Be sure surface of fossil is clean and free from extraneous debris.

2. Cover fossil and adjacent rock surface with a very thin seal coat of "Helen Neushaefer's Neu Colorless"[1] nail polish; break all bubbles as they form.
3. Dry for 30 minutes at room temperature.
4. Apply a second coat of polish, again breaking bubbles as they form.
5. Dry at room temperature for at least 30 minutes; then flood the surface with polish; spread evenly over the surface with as few brush strokes as possible to minimize air-entrapment and consequent bubbles.
6. Immediately apply a piece of .005 acetate film[2] (trimmed slightly larger than the coated surface), which has been softened for approximately 30 seconds in beta-methyl-cellusolve.[3] The acetate film is applied in a manner similar to that used in applying a cover glass to a slide.
7. Dry free from dust 48–72 hours at room temperature.
8. Loosen all edges of acetate with a scalpel or razor blade.
9. With a steady force simultaneously pull and lift the film from the rock.
10. Trim off excess acetate film.
11. Dry film between paper towels under weighted plate glass for about 12 hours to smooth film. The schedule may be terminated here temporarily and the films stored in envelopes. If complete removal of the clinging rock matrix is required, eliminate this step and proceed directly to step 12 of the schedule.
12. Place transfer in dilute hydrofluoric acid (20–25%) for from 5 to 60 minutes, depending, upon the amount of rock adhering to the carbonized compression. If the acetate film becomes cloudy in this step, it will clear in steps 14 and 16.
13. Remove from acid bath with paraffin-coated forceps; wash in luke-warm water; brush very gently with a fine camel's-hair brush to remove loosened rock matrix. If some matrix adheres to the film, re-immerse in acid bath, washing and brushing frequently to hasten action of acid.
14. Trim and place between paper toweling or lens tissues under a smooth weighted surface for about 12–24 hours.
15. Place in envelopes for filing or
16. Clear for a few seconds in xylol or Eycleshymer's solution.[4]
17. Mount in Canada balsam.

[1] Helen Neushaefer's Neu Colorless Nail Polish is obtainable in most drug and ten cent stores; quantity for scientific use only may be obtained from A. Sartorius and Co., Inc., College Point, N. Y.

[2] .005 weight acetate may be obtained from office supply stores as "Note-book separator" sheets or from "Cel-u-Dex"; E. J. Keller and Co., 500 N. Dearborn St., Chicago, Ill.

[3] Beta-methyl-cellusolve may be obtained from Works Laboratory, Carbide and Carbon Chemical Co., South Charleston, West Virginia.

[4] Eycleshymer's solution consists of equal parts of bergamot, cedar oil, and carbolic acid.

Better results are obtained if the transfers are made as soon as possible after the fossils have been collected. If the rock matrix is thoroughly dry, porous, or thin, the acetate film may be pulled in not less than 24 hours. If none of these conditions are operative, the applied acetate film should dry for not less than 48 hours for best results.

Frequently plant fossils are exposed on uneven surfaces. Before attempting to remove carbonized compressions, rock surface irregularities adjacent to the fossil should be reduced or eliminated in so far as practical. Extreme care must be taken to prevent the formation of small pits and narrow grooves in the rock for each invariably leads to the formation of one or more bubbles under the nail polish seal coat. Liberal application of acetone to pits and grooves with a fine brush will reduce the number of bubbles. If bubbles do form between the fossil surface and the first coat of nail polish, the carbon cannot be stripped from the matrix. If an uneven rock surface is unavoidable, the soaked acetate film can be pressed towards and over (never around) surface irregularities with the finger wetted in cellusolve. Fingerprints formed on the softened acetate during application of the film to the rock, disappear as the film dries. Scissors may be used to cut darts or slits in the film to make it fit the rock surface, provided the irregularities are well outside the periphery of the fossil. Additional nail polish must be applied after a cut has been made to assure a sealed joint. The central portion of the acetate film should never be punctured to eliminate bubbles; they may be eased out with the long dimension of a needle or more effectively with the fingertip moistened in cellusolve.

Clearing in xylol or Eycleshymer's solution yields excellent results when the carbonized pellicle is light to dark brown. Cell structures are frequently visible in such cleared materials. Nothing is gained by clearing in xylol when carbonization is heavy and opaque for it intensifies the brittleness of the carbon and usually causes it to flake off the acetate film unless mounted in balsam immediately.

Gross detail such as carbonized synangia are better defined when the acetate film is neither cleared nor permanently mounted. The small amount of adhering rock matrix outlines their features and gives them

depth which is lost in a large measure on clearing and mounting.

Sodium hydroxide is not used following the hydrofluoric acid bath, because reaction between the neutralizer and the acid renders the delicate tissue opaque and tends to cause the carbonized compression to flake off the acetate film.

Various brands of colorless nail polish have been tried; all except Helen Neushaefer's become permanently cloudy or turn white in steps 12 and 13. The same criticism is applicable to collodion and gun cotton. Various types of acetate film have also been tried. To date, all, except .005 weight, are, for one reason or another, unsuitable for the removal of carbonized film from the rock. The .005 weight acetate also turns white after prolonged immersion in hydrofluoric acid, but becomes transparent again upon drying.

Compressed sporangia or synangia may be removed successfully from the rock matrix by etching for about 5 minutes in 48 per cent hydrofluoric acid followed by careful washing, brushing, and slow drying (paper wrapped) prior to application of liquid acetate.

In the process of softening the acetate film, the length of the soaking period is very important. After 30 seconds in cellusolve, the acetate film stretches. In order to eliminate bubbles it must be immediately applied to the rock surface and fossil. Stretching and wrinkling continue for a short time after the film has been applied to the rock; however, as soon as drying begins, the film shrinks and continues to shrink to slightly less than its original size. If the stretched film should become cemented to all vertical edges of the rock, the acetate film will split during drying. Such a split can be successfully patched after the film is dry by applying a coat of nail polish and a small piece of soaked acetate. The patched film must dry thoroughly before the entire film is pulled.

Acetate films up to 4 by 6 inches have been successfully stripped from rock surfaces. The method applies equally well to clay-shale, sandy shale, and limonite films replacing carbon.

A NEW RODENT FROM SUBSURFACE STRATUM IN BEE COUNTY, TEXAS

CLAUDE W. HIBBARD[1] AND JOHN A. WILSON[2]

INTRODUCTION

In June of 1948 Dr. Dan E. Feray, then in charge of the Well Sample Library of the Bureau of Economic Geology of The University of Texas, discovered a fragmentary lower jaw of a geomyid rodent in an oil-well sample. The sample from which the jaw was recovered consisted of drill cuttings recovered from a depth of 1,280 to 1,300 feet. The jaw was examined closely for fragments of matrix adhering to the bone and teeth to determine whether or not the specimen belonged at that level or if it had dropped down from above. Unfortunately, the matrix was not sufficiently diagnostic to make an accurate correlation with samples above that level. The authors are, therefore, unable to assign a definite stratigraphic position to it. In spite of this, they feel it warrants description because it increases the knowledge of Cenozoic mammals as furnished by specimens recovered from well samples.

Simpson (1932) reported upon a new Paleocene mammal recovered from a core taken at a depth of 2,460 feet in Louisiana. Hesse (1934) reported upon a jaw of a fossil vole recovered from an upper Pliocene core taken at a depth of 3,174 feet below the surface in Kern County, California.

The authors are grateful to Dr. George G. Simpson of the American Museum of Natural History, Dr. Joseph T. Gregory of the Peabody Museum, Yale University, And Dr. C. Lewis Gazin of the United States National Museum for permission to study remains of Cenozoic geomyid rodents

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under their care. They are also indebted to Dr. John T. Lonsdale for permission to study and report upon this specimen.

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of anterior cingulum; base of lower incisors forms knob on ascending ramus; anterior face of upper incisors slightly rounded; slight supraorbital ridges, with no trace of their uniting to form a sagittal crest."

FIG. *1*—No. 40061, Bureau of Economic Geology, The University of Texas, *Grangerimus sellardsi* Hibbard and Wilson, holotype. Fragmentary right lower jaw, with base of P_4 and complete M_1–M_2. Lingual and occlusal views. ×5.

The specimen here reported appears to belong to the genus *Grangerimus* Wood, 1936.

Albert Elmer Wood (1936, p. 14) gave the following generic diagnosis based upon a damaged skull with lower jaws, from the lower Miocene, upper John Day beds, John Day River, Oregon: "Molars high crowned but rooted; P^4 with single cusped protoloph; slight tendency for development of lakes in upper molars; H-pattern in lower molars; P_4 with anteroconid but only a trace

LOCATION AND STRATIGRAPHY

The well from which the jaw was recovered is the United Production Company No. 32 George A. Ray located in the North Pettus field, which is a few miles north of the town of Pettus in Bee County, Texas, on the Habbermacker survey, 660 feet southeast of well No. 13 and 250 feet from the northeast line of the survey. The samples from this well in the Well Sample Library of the Bureau of Economic Geology bear the serial number 4575. This record shows that it was completed as a dry hole on February 27, 1931.

Samples from 0 to 552 feet were identi-

fied as Oakville formation, and samples from 552 to 2,405 feet were identified as Catahoula. The Oakville is Miocene and the Catahoula is Oligocene. It is possible that the jaw could have come from either one; however, the identification as *Grangerimus* would tend to favor a Miocene age.

GRANGERIMUS SELLARDSI Hibbard and Wilson, n. sp.

Holotype.—No. 40061, in the collection of the Bureau of Economic Geology of The University of Texas, part of right ramus bearing alveolus and roots of P_4, complete M_1 and M_2 and the anterior root of M_3.

Horizon and type locality.—Miocene or Oligocene. United Production Company No. 32 George A. Ray well from a depth of 1,280 to 1,300 feet (?), Bee County, Texas.

Diagnosis.—A geomyid rodent slightly smaller than *Grangerimus oregonensis* Wood. P_4 with anterior loph (protolophid) reduced. Metalophid of P_4 nearly as wide as protolophid of M_1. M_1 slightly smaller than M_2. M_3 slightly narrower than M_1 or M_2. Teeth high crowned. Enamel extends to base of crowns but not onto the roots. Pattern of M_1 and M_2 with further wear will produce an open U instead of an H-pattern. The protolophid and metalophid of M_1 and M_2 will join first on the labial side. The valley between the protolophid and metalophid of M_1 and M_2 is much deeper on the lingual side than on the labial side of the tooth. The valley of M_1 and M_2 with further wear will join lingually beyond the midpoint of the valley and will form an enamel island on the labial side of the tooth.

Description of holotype.—The type specimen is a fragmentary part of a right lower jaw lacking P_4 and M_3. The lower jaw is broken anteriorly at the posterior edge of the mental foramen. It is broken posteriorly at the midline of M_3 and no part of the ascending ramus is present. The specimen is well preserved and is white in color. Measurements are as follows:

	mm.
Alveolar length of P_4-M_3	5.90
Occlusal length of M_1-M_2	3.10
Occlusal length of M_1	1.50
Greatest width of M_1	1.85
Occlusal length of M_2	1.50
Greatest width of M_2	1.88

P_4 is represented only by the base of the tooth and its roots. The anterior root is small and seems to indicate a small protolophid. The posterior root is broad and appears to be divided since it possessed two nutritive canals. M_1 slightly narrower than M_2. The protolophid of M_1 is crescentic and the labial part nearly touches the labial edge of the metalophid. The protolophids and metalophids of M_1 and M_2 were three-cusped. The protolophid of M_2 does not possess as great a posterior projection on the labial side as is found in M_1. The lingual part of the valley on M_1 and M_2 is deep, wide, and extends well down on the side of the tooth. This character of the valley between the protolophid and metalophid distinguishes this form from *Diprionomys* Kellogg.

The masseteric crest is not pronounced, which may be due to abrasion. It ends well forward of P_4.

Because of the size of the specimen, the well-developed roots of the teeth, the fact that the enamel extends only to the base of the crowns of the teeth, the occlusal pattern, and the deeply developed lingual part of the valley of M_1 and M_2, the specimen has been assigned to the genus *Grangerimus*.

This species is named for Dr. E. H. Sellards, who has devoted much of his life to the study of Cenozoic mammals.

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TRINUCLEUS MURCHISON, 1839 AS A NOMEN CONSERVANDUM

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The name *Trinucleus* has been used in two very different ways in natural history since 1758. The first use was by Link (1807, p. 6), who employed the name for two trilobite fragments previously illustrated by Walch (1776, pl. 4, figs. 2, 3). Of these, one appears to be a fragment of a lichid glabella and the other, a somewhat diagrammatic drawing of a fairly complete trilobite with its damaged cephalon lying askew to the thorax; this latter trilobite may be a small illaenid or perhaps a proetid. Unless the original specimens are discovered, or topotypes from "Mecklenburg" are forthcoming, we consider that, from evidence at present available, these trilobites, which Link named *Trinucleus tuberculatus*, are both specifically and generically unidentifiable.

The other use of *Trinucleus* followed the pattern set in the late seventeenth and early eighteenth century in the works of Lhwyd and was given binomial status by Murchison in 1839. The first usage has remained unique, but the second has become one of the most common names in trilobite literature.

By strict application of the rule of priority the name *Trinucleus* Murchison, 1839, should be replaced. In most cases, the suppression of a trilobite name is of little importance, and of interest only to specialists, but *Trinucleus* Murchison is not an obscure name. It is well established and known to many not directly concerned with the nomenclature of the Trilobita. It has found its way into textbooks of stratigraphy and of general geology as well as into strictly paleontological publications. It is, moreover, the type of a prominent family of Ordovician trilobites, the Trinucleidae.

Therefore, it seems proper to us that the name *Trinucleus* Murchison be submitted to the International Commission for Zoological Nomenclature with a request that it be designated a nomen conservandum, displacing the unused *Trinucleus* Link, 1807.

It is in order to acquaint interested parties with this impending action that this notice is published. We sincerely request all those who have comments on the matter to communicate them to us in order that we may submit as full a summary of opinion as possible to the Commission.

THE TYPE SPECIES OF *Trinucleus*

Some confusion has arisen regarding the correct designation of the type species of *Trinucleus* Murchison. *T. fimbriatus* is commonly cited as the type because it was so listed by Raymond in the 1913 edition of the Zittel-Eastman Textbook,

However, the type is actually *T. caractaci* Murchison, 1839. This species was first chosen by Raymond early in 1913 (Raymond, 1913A, p. 140), but the selection raised a storm of protest because it led, it was believed, to the suppression of *Trinucleus* in favor of *Cryptolithus* Green, 1832. In response to this protest, and in order to retain *Trinucleus* Raymond (1913B, p. 29) later chose *T. fimbriatus* as type species, the procedure he followed in the Zittel-Eastman text. Clearly, under the Rules, the type species must be *T. caractaci*.

In 1929, Bancroft proposed the new name *Salterolithus* for the species of the type of *T. caractaci*. This name is a direct synonym of *Trinucleus* Murchison. Thus, two generic names have been applied to *T. caractaci*, but none is available for *T. fimbriatus*. Therefore, the new name *Edgellia* Shaw is here proposed, with *Trinucelus fimbriatus* Murchison, 1839 (Murchison, 1839, pp. 650, 660, pl. 23, fig. 2), as type species. The name is chosen in belated recognition of the centenary of the birth of Henry Adrian Wyatt-Edgell, whose promising career was cut short at the early age of nineteen, but who, nevertheless, managed to leave behind a record of his interest in the trilobites.

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NOMENCLATURAL NOTE

GENUS DESIGNATION FOR SPECIES IN EVOLUTIONARY TRANSITION

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In his thought provoking essay on "The State of Paleontology" Maxim K. Elias (1950, p. 149) proposes to use the name of the older genus combined with that of the younger one, the latter to be put between square brackets, for generic designation of species in evolutionary transition between both.

Although exception may be taken to Elias' speaking, in this connection, of "nomenclatorial recognition of a new kind of paleontological subgenus" and of using "the name of the succeeding genus . . . in a subgeneric sense," since the younger genus would, in such usage, be coordinated rather than subordinated to the older one, his suggestion might well prove an expedient where it seems impossible to decide to which of the two genera to assign a given species transitional between them. It is a different question if this suggestion will be able to assert itself successfully in the face of general inertia and gain nomenclatorial recognition in the Rules.

It would seem, however, that Elias' proposal might be improved by merely inserting a hyphen between the two generic names without putting the younger one between square brackets; e.g., in the first of the two examples chosen by Elias (loc. cit.) the generic designation would read "*Chonetes-Mesolobus*" rather than "*Chonetes* [*Mesolobus*]," as suggested by the author. The former version would not only be less cumbersome but also exclude any misunderstanding, as if the younger genus were a subgenus of the older one.

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NOTICES

The following request was recently recieved by the Secretary of the Paleontological Society:

The Zoological section of the International Union of Biological Sciences has received a grant from UNESCO for the publication of a List of Zoologists.

We are sending you, as to all other zoologists that we know of, a form to fill in. Will you please do so and return it to us; it will be placed in our files and then printed.

This list must be kept up to date for future editions; therefore we count on you to write to us should this be useful and particularly to notify us of a change of address or degree; let us know of any special events that may take place around you or of the death of any fellow zoologists.

Please tell anyone that this may interest so they can write to us for a form; and try to interest in our plan any young beginners in zoology.

All correspondance should be addressed to the secretary's office: MR. E. FISCHER-PIETTE, PROFESSEUR AU MUSÉUM, 55, RUE DE BUFFON, PARIS 5e.

The committee on the Illustrated Catalogue of North American Devonian Fossils announce the publication of the third instalment of cards on the corals. This unit (1-E, part c) contains 146 cards, and completes publication of the family Favositidae. Preparation of the unit was done by Dr. E. C. Stumm of the University of Michigan.

Unit 1-E, part c is priced at $13.00, with postage and packing extra. Copies of this and most of the other units previously published may be obtained from the Wagner Free Institute of Science, Philadelphia 21, Pennsylvania.

PALÄONTOLOGISCHE *ZEITSCHRIFT*

The Paläontologische Gesellschaft of Germany is attempting to resume publication of its Zeitschrift. Several papers are scheduled for publication in the autumn of 1950, provided funds become available. The addition of one hundred new members to the society would provide money for issuance of the first bulletin. Hence, support by paleontologists outside Germany would be welcomed. Membership dues are 15 German marks—about $4 per year. Correspondence may be addressed to the Treasurer, Dr. Heinrich Hiltermann, Hannover, Am kleinen Felde 12, Germany (British Zone).

A. MYRA KEEN

NEW JAPANESE PALEONTOLOGICAL JOURNAL

The Institute of Geology and Paleontology of Tohoku University, Sendai, Japan recently has announced plans for a new publication known as "Short Papers" of the Institute. It is to contain articles on geology, paleontology, and related sciences contributed primarily by members and graduates of the Institute at Tohoku University. The first number, scheduled to appear in June, 1950, contains nine papers of which all but one are paleontological; three deal with Tertiary Foraminifera, two with Tertiary and Permian plants, and one each on echinoderms, brachiopods, and a Pleistocene marine fauna; a stratigraphic paper deals with one of the Tertiary formations of the east coast of Japan north of Tokyo. The editors of "Short Papers" are Shôshirô Hanzawa, Kiyoshi Asano, and Kotora Hatai.

Copies of this new publication (all articles of the first number in English) will be distributed to institutions throughout the world on an exchange basis. Approximate cost of individual numbers is fifty cents to one dollar depending on size, but request for information about subscriptions should be addressed to Professor Hanzawa.

RAYMOND C. MOORE

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In accordance with Article 3, Chapter 1 of the By-Laws of the Society, the Secretary submits the following names of applicants for election to membership for consideration by the Members of the Paleontological Society.

WILLIAM TOLLIVER ALLEN, United States National Museum. Museum Aid. J. B. Knight, A. R. Loeblich, Jr., G. A. Cooper.

HAROLD V. ANDERSON, School of Geology, Louisiana State University, Baton Rouge, La. Ph.D. candidate, La. State 1950. A. S. Warthin, H. V. Howe.

GORDON LENNOX BELL, 2609 Acadia Rd., University Hill, Vancouver, B. C. BA U. B. C. 1949; Assistant in Paleontology. V. I. Okulitch, M. Y. Williams.

JOHN S. BRADLEY, Dept. of Geology, University of Washington, Seattle 5, Wash. Geol. Eng., Colo. Sc. Mines 1948. C. E. Weaver, H. E. Wheeler.

DONALD EDMUND CAMPEAU, 1439½ Eureka St., Lansing, Mich. BS Mich. St. 1949; MS 1950. W. A. Kelly, B. F. Howell.

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JOHN CHRONIC, 1461 University Terr., Ann Arbor, Mich. BS Tulsa 1942; MS Kans. 1947; PhD. Columbia 1949. G. M. Ehlers, E. S. Stumm.

CLIFFORD C. CHURCH, 1828 Bryant St., Palo Alto, Calif. AB Okla. 1923; MA Stanford 1925. W. H. Easton, O. L. Bandy.

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SANFORD PAYNE FAGADAU, Dept. of Geology, Ohio State University, Columbus, Ohio. BSc Ohio State 1947; MSc 1949. Grace A. Stewart, A. La Rocque.

DAN EDWARDS FERAY, Geol. Department, Univ. of Tulsa, Tulsa, Okla. BS Tulsa 1939; MS Ill. 1940; PhD Wis. 1948. E. N. K. Waering, K. E. Caster.

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EUGENE P. LANCASTER, Shell Oil Co., Tulsa, Okla. BS Okla.; AM 1936. E. N. K. Waering, R. V. Hollingsworth.

LESLIE W. LEROY, Colorado School of Mines, Golden, Colo. Geol. Eng., Colo. Sch. Mines 1933; D. Geol. Eng. 1945. W. H. Easton, O. L. Bandy.

VIRGIL S. MALLORY, Paleontology Museum, University of California, Berkeley, Calif. AB Oberlin 1946; AM Univ. Calif. 1948. R. M. Kleinpell, R. A. Stirton, J. Wyatt Durham.

WOLF MAYNC, Apartado 893, Caracas, Venezuela. BA 1930; PhD 1936. H. E. Thalman, W. E. Humphrey, K. E. Caster.

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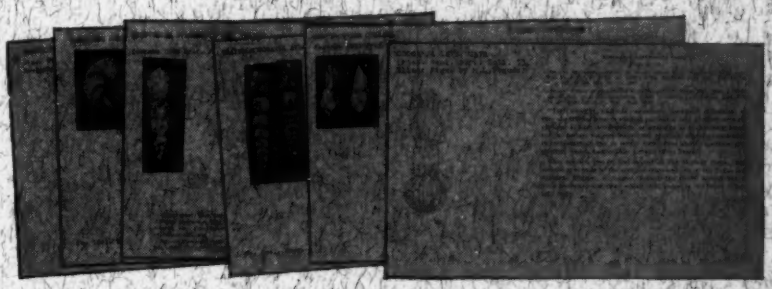

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